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Water Treatment by Coagulation, Sedimentation and Hypochlorite Disinfection at Omaha, Neb.

By FRANCIS H. MARSHALL.*

Before describing the treatment of water by hypochlorite of lime, as applied by the Omaha Water Co., it will be not only advisable but also necessary to give a short sketch of the construction and general arrangement of the settling reservoirs at Florence, Neb., from which Omaha takes its water-supply.

The main settling reservoirs, five in number, are located in Florence about six miles north of Omaha on the right bank of the Missouri River (see the view, Fig. 1, and the plan and details, Fig. 2). The two small auxiliary reservoirs, A and B, were constructed chiefly for the purpose of adding to the necessary sedimentation and to the further aeration of water as it flows over the weirs, the matter of eliminating sediment being a great factor, as every one who is acquainted with the "Big Muddy" knows, in transforming its water into a drinkable and palatable beverage.

The supply to the reservoirs, which is taken from the river through a 48-in. suction pipe, is delivered by a 20,000,000-gal. Allis pumping engine to either Basin No. 4 or No. 5, from which the water flows over the weirs until it reaches Basin A, at which point it is conducted through conduit pipes to Basin B, thence over the weirs again to what is known as Clear-Water Basin No. 1. During the winter months when the overflows are not in operation, owing to the effects of ice, the water is conveyed from one basin to the other through conduit pipes, as is shown by the broken lines on the plan, Fig. 2.

In order to aerate the water more thoroughly during its passage over the weirs, a system of tee irons was installed in rows lengthwise, embedded in concrete, the arrangement of which is shown in Fig. 2.

For the purpose of facilitating the washing and cleaning of the reservoirs, a system of mud valves, opened and shut by hydraulic power, was introduced. These valves are located at the lowest points of pockets or divisions into which the bottoms of the reservoirs are divided and the valves are connected with sewer pipes (see dotted lines, Fig. 2) which in turn carry off the deposit into a main sewer to the river. As only a small percentage of the mud is carried away by this means, five or six connections are made to a high-pressure pipe-line with 2-in. hose attachments in order to clean the sides and bottom. The time usually taken to clean the reservoirs is not more than twelve hours for the large and four hours for the smaller basins from the time of opening the valves. The fast accumulation of mud necessitates the cleaning of Basins 4 and 5 every two weeks alternately, Basin 3 every three months, Basin 2 every two months and Basin 1 once a year.

In order to help clarify the water, alum is used to induce precipitation. Two concrete tanks have recently been constructed between Basins 4 and 5, with a capacity of 5,000 gals. each, delivering the alum solution through 2-in. perforated pipes situated along the highest ridge of the overflow into Basin 3. The amount of alum used is in the proportion of 2 grains per million gallons, gaged by valves at the outlet of the alum tanks to give continuous and even flow.

The original Omaha water plant is located on the river front due east of the city and is used now as an auxiliary station, only. It consists of five basins, very similar in operation to those at Florence, but of much smaller dimension, furnishing about 3,500,000 gals. per day, while the Florence plant supplies an average of nearly 17,000,000 gals. for city consumption.

Hypochlorite of lime is used at both stations, similar tanks, only smaller, being operated along the same methods; therefore the description of one will suffice for both.

Owing to an unusual number of typhoid cases in the winter of 1909-10, it was thought advisable to treat the water-supply, although it was far from certain that water pollution was the cause of the disease. After mature consideration, it was decided to enlist the aid and advice of a sanitary expert as to what should be done to better the

*Chief Engineer, Omaha Water Co., Omaha, Neb.

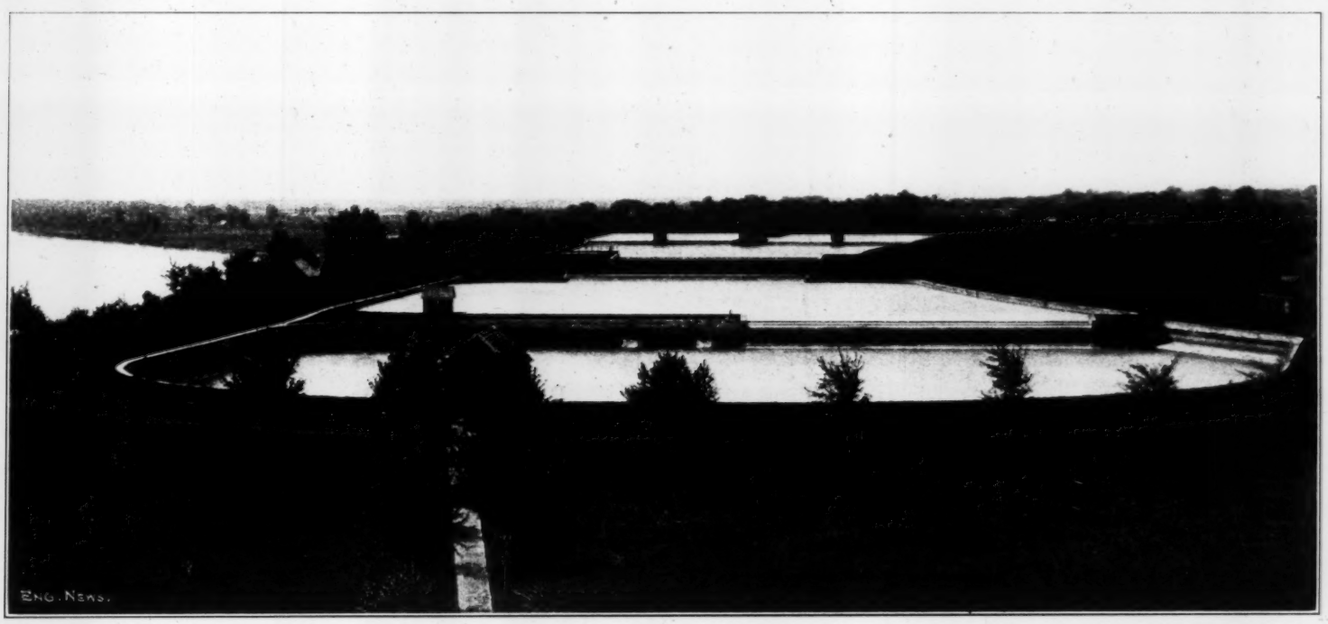


FIG. 1. GENERAL VIEW OF COAGULATING AND SETTLING RESERVOIRS OF THE OMAHA WATER CO., LOCATED AT FLORENCE, NEB.

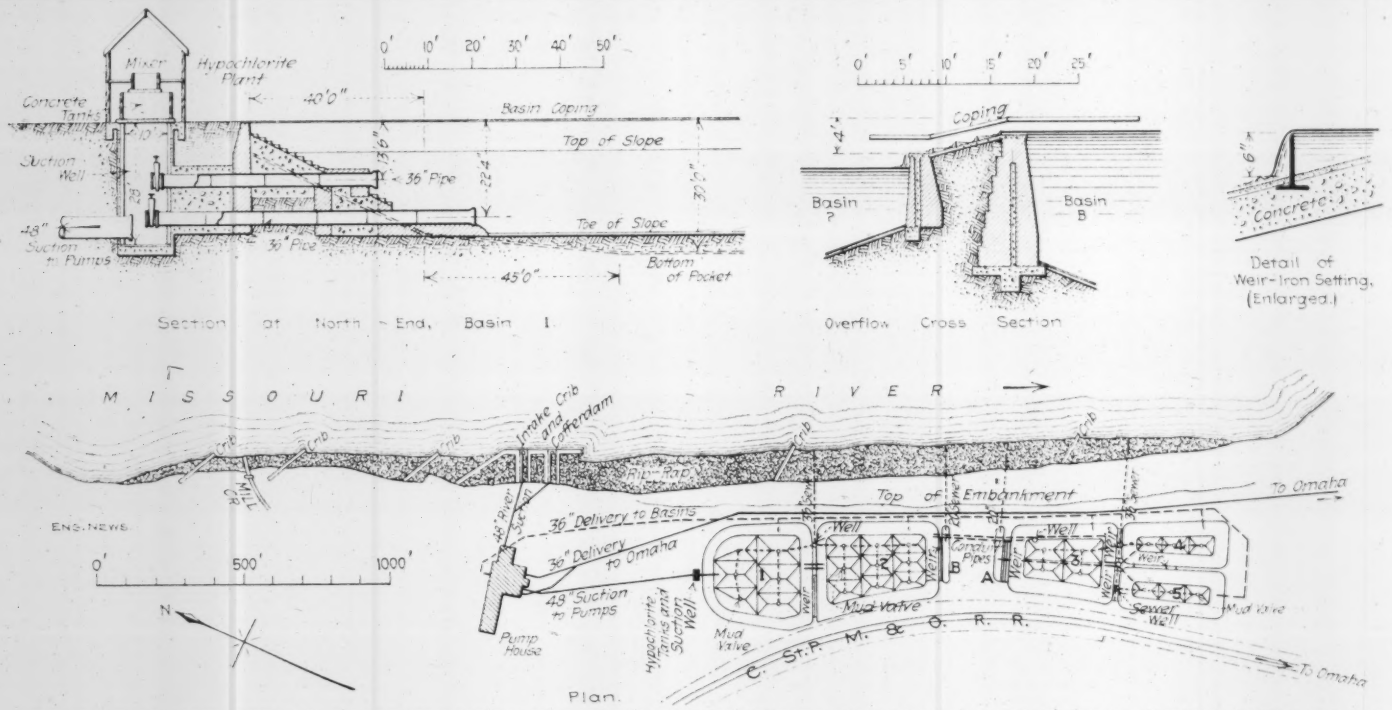


FIG. 2. PLAN AND DETAILS OF COAGULATING AND SETTLING RESERVOIRS, AND HYPOCHLORITE PLANT, OMAHA WATER CO.
(Basin No. 1 has a capacity of 20,000,000 gals.; Basin 2, of 20,000,000; Basin 3, of 15,000,000 gals.; Basins 4 and 5, each of 7,500,000; Basin A, 4,750,000 gals.; and Basin B, 4,360,000; giving a total capacity of 79,110,000 gals.)

existing conditions. Dr. J. L. Leal, of Paterson, N. J., was requested to report on the cost and location of a disinfecting plant capable of meeting the requirements for the purification of the water. After looking over the situation, he decided that treatment by hypochlorite of lime would be the most effective plan that could be adopted. Accordingly, plans of the tanks and mixers, etc., were submitted and buildings erected, and the plant was ready for operation by May 1, 1910.

The two solution tanks are constructed of concrete, with a diameter of 11 ft., walls 6 ins. thick, a depth of 6 ft., and a capacity of 4,200 gals. each. Above these, with its circular base resting on and overhanging the solution tanks, is what is termed the mixer, of concrete construction also, 5 ft. 8 ins. in diameter, 4 ins. thick and 3 ft. 6 ins. deep, inside measurement, with a capacity of 660 gals. Wooden tanks were used at the time of installation of the plant, but owing to the disintegrating effects of the solution they were soon out of commission, and were replaced by the present concrete reproductions.

A small, well-equipped laboratory on the second floor of the building was found necessary for bacteriological work, such as making counts of raw, settled and treated water at Florence, and taking samples in different parts of Omaha at short intervals.

The tank house, as shown by Fig. 2, is situated directly over the suction well north of Basin 1, thus insuring a thorough mixing of the solution with all the water intended for city distribution.

The proper amount of lime, varying according to depth of solution remaining in the tank from the previous days' run, is weighed and placed in the mixer, with enough water to form a thick paste, which is made by revolving paddles worked by water-power; by this means all lumps are thoroughly broken up. As shown by Fig. 3, a perforated pipe runs around the bottom of the tank, fed by water under 120 lbs. pressure, and is used for filling the tank. This needle shower, as it might be called, assists considerably in the mixing and keeps all the particles, which have a tendency to settle, off the bottom. The valve leading to the solution or storage tank can now be opened. A supply pipe can be used to assist in filling should occasion require. In order to prevent large particles of lime from entering the solution tank while filling, a brass screen is placed over each outlet.

The solution tanks hold about a 32 hours' supply of 0.5% solution each. Paddles similar to those used in the mixer are used in these tanks, with the difference that those in the solution tanks do not cover as much area in proportion to the size of tank. The use of these paddles is to insure a more uniform strength of solution; without them the strength at the top of the tank is considerably weaker than at the bottom, viz.: 10 cc. of the solution should have required 5 cc. of the N/10 arsenious, but a sample taken when the tank was first turned on required 5.8 cc. and another taken just before the tank was emptied required but 3.9 cc. It was found that if the solution were thoroughly mixed before using, the stirring could be discontinued while the tank was in use and the clear solution would be uniform in strength and much easier handled. It was also found that the milky solution, the result of continuous stirring, clogged up the orifice boxes in the course of a day's run. These orifice boxes are in duplicate and located over the suction well, the solution being carried

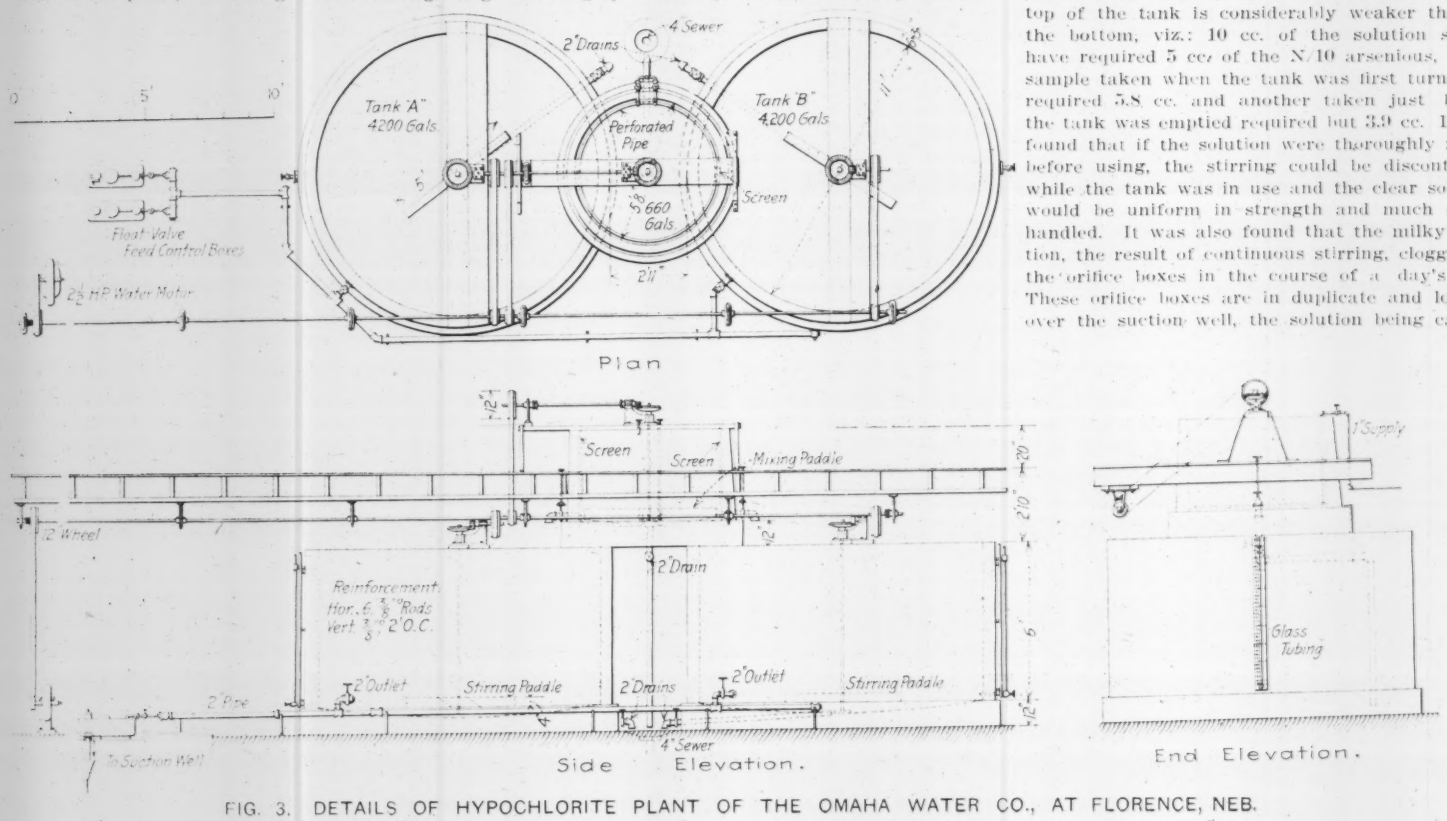


FIG. 3. DETAILS OF HYPOCHLORITE PLANT OF THE OMAHA WATER CO., AT FLORENCE, NEB.

BACTERIAL RESULTS OBTAINED WITH SEDIMENTATION AND COAGULATION AND WITH HYPOCHLORITE DISINFECTION, OMAHA WATER CO., OMAHA, NEB.

Month, 1910.	Bacteria per cc. Total count. Raw.	Settled.*	Disinfected.	B. Coli. Raw.	Settled.	Disinfected.	Average chlorine.†
May	11,726	393	102	9— 7+	7— 9+	15— 1+	.290
June	21,330	588	65	12— 18+	3— 27+	29— 1+	.366
July	25,467	642	42	10— 21+	3— 28+	31—	.381
August	38,803	549	33	2— 20+	2— 29+	31—	.349
September	78,200	1,042	35	1— 30+	1— 29+	28— 2+	.364
October	34,300	897	18	17— 14+	1— 30+	31—	.393
November	22,320	782	23	17— 13+	0— 24+	30—	.387
December	11,670	1,357	23	12— 9+	18— 3+	21—	.307
Average	30,477	781	43				.355
Percentage reduction of bacteria in raw and settled water							97.4
Percentage combined efficiency of settling and treating							99.85

*Sedimentation is assisted by the use of sulphate of alumina.
†Available chlorine in parts per 1,000,000.

from them to the mouth of the 48-in. suction to the pumps through a perforated pipe. Theoretically, under a 6-in. head, a known feed would result, but at times the orifice tends to clog up. To regulate the feed, hourly readings are taken on the glass gages attached to the storage tanks.

When the treatment was first begun a 0.5% solution was tried, afterwards a 1%; at present a 0.5% is used, as it gives better results. Varying parts per million available chlorine were tried from .25 to .45; .30 parts gave most satisfactory results.

The results of the treatment since its installation last May is shown by the accompanying table. The percentage of bacterial reduction in the basins before treatment is 97.4 and the combined efficiency of the basins and the treatment is 99.85%.

For the bacteriological data and prints of the plant, the writer is indebted to Mr. Jay Craven, who has been in charge of the work since May, 1910, in the employ of The Omaha Water Co., under the direction of Dr. J. L. Leal.

The cost of installing the chlorination system at both stations, including buildings, was about $6,000; the cost of the Florence plant alone was about $3,750.

Cracking of Cement-Grouted Brick Pavements: Causes and Remedies.*

By EARLE R. WHITMORE.†

The following are the causes of cracks in brick or block pavements which the writer has observed; and they are placed, he believes, in the order of their importance and frequency of occurrence, and will be discussed separately in that order:

(1) Frost.
(2) Expansion.
(3) Settling of sand cushion.
(4) Settling of sub-grade.
(5) Contraction between transverse expansion joints.

The writer fully appreciates the fact that this is not the order of precedence in which these causes of failure would be placed on information obtained from the preponderance of technical literature on the subject, but believes that careful observation will prove it to be the correct arrangement, nevertheless.

Frost.

The writer's observations seem to him to prove beyond doubt that the longitudinal crack along the crown of the pavement (or sometimes several feet to one side of the crown) are nearly always, if not always, caused by frost. This is the cause which the average layman usually assigns, and perhaps that is the reason that the average engineer, in his assumption of wisdom, is convinced that it is the wrong solution.

The following observations support the layman's theory:

(a) These longitudinal cracks invariably first appear in the form of a very small and significant appearing crack, *when the snow goes off in the spring.*

(b) Where the sub-soil is clay, *the cracks are found where ample expansion joints are provided next the curb,* as well as where there are no expansion joints.

(c) Where the sub-soil is sand, or on fills where there is good natural drainage, these cracks are "conspicuous by their absence," *even where there are no expansion cushions.*

(d) The cracks follow along the line of travel on the street (usually near the crown), where the snow is packed by traffic during the winter and the frost penetrates deepest. Where there are one or more car tracks on the street, there is usually a crack along the driveway each side of the tracks, if the subsoil is impermeable clay or of such a nature as to retain water. At intersecting streets which *cross* the paved street, the crack does not continue across the intersection (presumably because the travel across the street and around the corners packs the snow and permits the frost to penetrate over sufficient area to raise the pavement uniformly without breaking it); but where the intersecting street comes in *from one side only,* the crack runs off toward the opposite curb as it approaches the intersection, and continues across the intersection, coming back to the crown again on the other side.

(e) A careful examination of the concrete foundation under the longitudinal crack will reveal the fact that the foundation is also cracked.

Is this expansion? And yet the specifications of the National Brick Manufacturers' Association, admirable and complete in most respects, make no provision for drainage except the statement that

if the ground is spouty clay, tile drainage should be provided to carry off the accumulation of wet;

and even this meager suggestion is modified by the statement that

Underdrainage is not absolutely essential, but in wet and spouty clay understratum much is added to the durability of the structure by keeping the sub-foundation dry, and under foregoing wet conditions is the only way to accomplish the best results.

No mention of frost. The report of the Asphalt Committee of the Organization for Standardizing Paving Specifications provides for drainage

when the soil is of such a character that it retains an excessive amount of moisture, such as clays subject to swelling or heaving under the action of frost;

but the report of the Brick Committee makes no mention of underdrainage. Technical books also are uniformly vague on this subject, and the inexperienced engineer has little indeed to warn him of the danger of frost.

Inasmuch as it is an established fact that frost has no tendency to swell or heave any kind of soil from which the moisture is thoroughly drained, the writer ventures the opinion that the best way to prevent this form of cracking is to provide a suitable drain under each curb where the subsoil is clay, and connect same with sewer inlets. Such drains should be placed about 3 ft. below the top of the curb, and the trench over the drain filled up to the bottom of the curb with coarse material, such as cinders or small fieldstone.

Placing cross-drains under the pavement is probably to be discouraged, as water cannot penetrate through the pavement after it is once built, and there seems to be little necessity for making provision for carrying water from the middle of the pavement toward the curbs; and these cross-drains tend to carry water under the pavement during the wet season, where it may percolate through the sub-grade, rather than to remove it.

Too shallow side-drains are also to be guarded against.

The writer does not consider his observations sufficiently final to warrant the omission of expansion cushions next the curb, in view of the fact that all modern paving specifications require such expansion cushions. His personal opinion, however, is that they seldom if ever serve any useful purpose except on very wide pavements. It is undeniably true that after the crack is once started it continues to widen from the action of alternate expansion and contraction; but I have never seen a crack of this kind that appeared to have been caused by expansion originally.

Expansion.

Expansion cracks occur on a hot day in summer, usually at a crown in the longitudinal grade of the paved street, when several courses of brick are sometimes thrown into the air with considerable violence, and when the repair gang comes to relay them they find that there is at least one row of the blocks which were thrown out that cannot be relaid.

This form of cracking is quite spectacular, and furnishes exceptional opportunities for advertisers of bituminous fillers. At the same time the damage to the pavement is comparatively slight and easily repaired.

Where there is no abrupt change of grade to permit the pavement to buckle, the observations of the writer seems to indicate that the filler between the brick courses is sometimes crushed in places, and the surface cracked into diamond-shaped or triangular divisions, the cracks following the joints and seldom breaking a brick. If there is a bend or angle in the paved street, the effect of expansion will be carried to this point of weakness, and will shove the angle considerably out of line.

The specifications of the National Brick Manufacturers' Association provide expansion cushions along the curbs only—no transverse joints. The report of the Brick and Granite Block Committee of the Organization of Standardizing Paving Specifications also provides for longitudinal expansion joints only, being practically copied from the specifications of the National Brick Manufacturers' Association. I understand that the secretary of the association, Mr. Will P. Blair, maintains that the longitudinal expansion, failing to find room to act longitudinally, is in some mysterious manner transformed into transverse expansion, and is then taken care of by the side cushions. This may be true to the extent that the breaking of the surface into diamond-shaped or triangular areas probably has a tendency to force the brick apart and outward toward the curb to some extent; but this is taking care of the expansion after it has done its damage.

These diagonal cracks, zigzagging along the brick joints, are inconspicuous, and in fact are often not visible except at such times as foggy mornings, when each crack is outlined by a line of moisture. They are not conspicuous like the longitudinal crack caused by frost, and make no spectacular explosion like the failure by buckling of the paved surface; but they extend over the whole surface of the pavement, tending to destroy its waterproof condition, and forming starting points for the jar of heavy traffic to begin its destructive action; and no doubt shorten the life of the pavement much more than the widely advertised buckling, which is all in one place and easily repaired.

It is believed that the most logical method of preventing this form of failure is to provide frequent transverse expansion joints, and that these joints are best formed by laying several courses of brick about one-fourth inch apart and filling these quarter-inch joints with a suitable bituminous filler before grouting the balance of the pavement.

The use of single expansion joints one-half inch or more in width is to be condemned for several reasons; it makes a bump for loaded vehicles, causing a hammering action on the adjoining brick which soon loosens them, and the fault thus started spreads rapidly under traffic; the bituminous filler is very apt to run in a wide joint, from the crown toward the curbs, in warm weather; the expansion sometimes forces the bottoms of the blocks next the expansion joint together, while the tops are held apart by earth, etc., which has become packed into the joint, causing the brick to heave up next the joint.

Settling of Sand Cushion.

This occurs from several sub-causes:

(a) If the sand cushion is spread on a macadam foundation, it is apt to work down into the foundation in places and cause unequal settlement, thereby breaking the paved surface. One or two cities, at least, have had disastrous results from attempting to lay brick pavements on macadam foundation in this manner. It could probably be avoided by filling and rolling the macadam foundation in about the same manner as for a finished macadam pavement, but there would usually be no economy in that. It is believed that a good concrete foundation is the most economical in the long run, unless possibly under some very exceptional conditions.

(b) If sufficient care is not exercised in forming the surface of the concrete foundation parallel with the plane of the required pavement surface, the sand cushion will be of varying thickness, and therefore liable to settle unevenly.

(c) The foundation having been properly laid, if the cushion is carelessly footed it will still be of unequal thickness; or if spread with a templet, and the templet is not carried back and drawn over the surface several times, the surface will invariably be wavy and cushion of unequal thickness.

It is a serious mistake to leave the sand cushion uneven, depending on the rolling to level it. The roller will probably make it appear quite level, but some of the blocks will be well bedded while others will have re-

*The greater part of a paper presented at the annual meeting of the Michigan Engineering Society, January, 1911.
†City Engineer, Port Huron, Mich.

ceived practically no benefit from the rolling, and these will naturally settle later under traffic.

(d) If the sand is partly dry and partly moist when spread, it will naturally settle unevenly. If the sand were all uniformly moist, the settlement would perhaps be as uniform as though dry sand were used; but a pile of sand is often dry on the outside and damp inside, or vice versa, and may not be thoroughly mixed in spreading. When such sand is used it should be dried, or if it were moistened uniformly by sprinkling the same purpose might be served.

Cracks caused by settling of sand cushion are usually roughly rectangular, do not break across the bricks, and the inclosed rectangle drops below the balance of the pavement. These rectangles vary in size from two or three bricks to several square yards. They go down under traffic sufficiently heavy to break the bond of the grout, and if the bond does not break an arch is formed, giving rise to the rumbling noise so often complained of. If not repaired at once the fault spreads rapidly, under the hammering action of traffic, over the surface of the adjoining pavement.

The proper thickness of the sand cushion has been the subject of much discussion. The writer believes that any thickness from 1 to 2 ins. is all right, if properly applied. Some have claimed that a mortar-bed in place of the sand cushion is the panacea for all these difficulties; it is probable that a mortar-bed properly prepared would give satisfactory results, as it has been extensively and successfully used for creosoted wood block pavements. The sand cushion is probably equally good, or better, if carefully and properly handled.

Settling of Sub-Grade.

This form of failure is also due to various sub-causes:

Pavements laid across fills are very apt to settle. It is only with the greatest care that a fill can be made so that it will not settle more or less.

Improperly-filled trenches for sewer, water and gas pipes, etc., often cause settlement many years after the pavement is laid. The pavement arch is strong enough, perhaps, but as the earth from the sides of the trench is gradually jarred down the span widens until it becomes too broad to support the load of traffic. Too great care can hardly be exercised in properly backfilling such trenches.

Very wet and undrained sub-grade sometimes is the cause of this trouble. Suitable side drains would usually remedy the matter when moisture is the cause.

Contraction Between Transverse Expansion Joints.

When expansion joints are placed a considerable distance apart, it is noted that fine cracks appear at intervals, following the grouted joint from curb to curb. Where expansion joints are 50 ft. apart two such cracks appear in the 50 ft., dividing the pavement into sections about one rod in length. These cracks are hardly noticeable, and sometimes can only be observed at certain times when outlined by moisture.

It is believed that they should be obviated by placing the transverse expansion joints only about 15 ft. or a rod apart. It would then be necessary to fill only one or two joints with the bituminous filler at each place.

The Traveling or Portable Hypochlorite Water-Disinfecting Plant of the Minnesota State Board of Health.*

By J. A. CHILDS† and H. A. WHITTAKER.†

In Engineering News for Sept. 10, 1910, mention was made of an emergency hypochlorite plant, then in process of construction. This plant was to be owned by the Minnesota State Board of Health and kept in readiness for immediate use in the event of an unforeseen pollution of a municipal water-supply.

The first portable plant was completed about Oct. 7, 1910. Only one plant of this type was provided but at present several of the later and simpler type are being constructed for emergency use. The first plant was used at Baudette, Oct 13, 1910, during a typhoid epidemic.

Requirements of Plant.

In designing this plant the following requirements were kept in mind:

(1) Light weight and compactness. To facilitate easy, cheap and rapid transportation.

(2) Low cost. Parts of the plant may frequently be lost or destroyed, and must be replaced.

(3) Simplicity. There must be no complicated or delicate mechanism which can get out of order.

(4) Ease of erection. It is of the utmost importance that the plant be of such a nature that the least possible time be lost in setting it up, since peoples' lives may be in danger in the meantime.

(5) Simplicity of operation. The plant must often be entrusted to untrained men.

(6) Adaptability. The plant must be designed to treat the water supplies of municipalities using 25,000 gals. per day or less, or of those consuming over 1,000,000 gals in 24 hours.

Description of Plant with Changes Made and Reasons for Same.

The apparatus finally adopted for this work consists of a mixing tank, solution pump, storage tanks, regulating apparatus, and necessary connections.

The mixing tank in the first plant was of sheet-iron and was built according to the design shown by Fig. 1. The mixing in this tank is effected by means of a 6-in. two-blade propeller, driven at the rate of 800 to 1,000 r. p. m. by means of a ¼-HP. electric or water motor belted to the pulley wheel at the top of the mixer. The propeller is located in the small end of the hollow cone and drives the water up through and down around it with such force that the hypochlorite is thoroughly mixed.

This steel mixing tank was a decided success as a mixer, but it was found to be too heavy for easy transportation. It was also found that a suitable source of power was not always convenient. For these reasons the power-driven steel mixer was discarded and the hand-driven barrel mixer shown in Fig. 2 was substituted. While this barrel mixer is not as efficient as the mixer of the type shown by Fig. 1, it is, however, much easier to transport, cheaper to construct, and meets all the requirements of a temporary plant. In this mixer the hollow steel cone is attached to and revolves with the vertical shaft. The two inclined blades, attached to the outside of the cone, serve as agitators which stir up any hypochlorite which settles to the bottom.

The storage tanks are simply 50-gal. air-tight oak barrels, equipped with nipples and valves as shown by Fig. 3.

The regulating apparatus consists of a 5-gal. oak keg, through the bottom of which is passed a ½-in. brass pipe in which a 3/16-in. hole is drilled. A rubber cork, held against the bottom of the keg by means of an iron plate (see detail Fig. 3) prevents leakage, and allows the pipe to be moved up and down. The method by which the surface of the solution in the regulating keg is kept at a constant height is described below. Experience has demonstrated that elaborate regulating devices with float valves, orifice boxes, etc., such as are often used in filter plants for the application of alum solutions, are not suited for administering the extremely small quantities of hypochlorite solution usually required to treat the water-supply of the average municipality in Minnesota.

Experience has also proven that the gate type of valve is the most satisfactory on account of the ease with which it may be cleaned. Valves of other types are more difficult to clean when they become clogged, as frequently happens when using a hypochlorite solution.

To facilitate rapid installation rubber hose is used to connect the various parts of the apparatus.

Operation.

The operation of the plant is as follows: (see Fig. 3).

The required amount of hypochlorite is placed in the mixing tank, which is then filled with water and thoroughly mixed. After a half hour's settling to remove the hypochlorite which does not dissolve, the solution is either pumped, or allowed to flow by gravity, to one of the air-tight storage barrels.

Consider storage barrel "B" empty, and storage barrel "A" filled. Valves 1-3-6 and 8 are closed. Valves 2-4 opened. The solution will flow from storage barrel "A" through valve 4 into the regulating keg and below the surface of the solution in the keg. Air to replace the solution thus drawn off will enter storage barrel "A" through the hose connected with valve 2 until the surface of the solution in the regulating keg rises to the

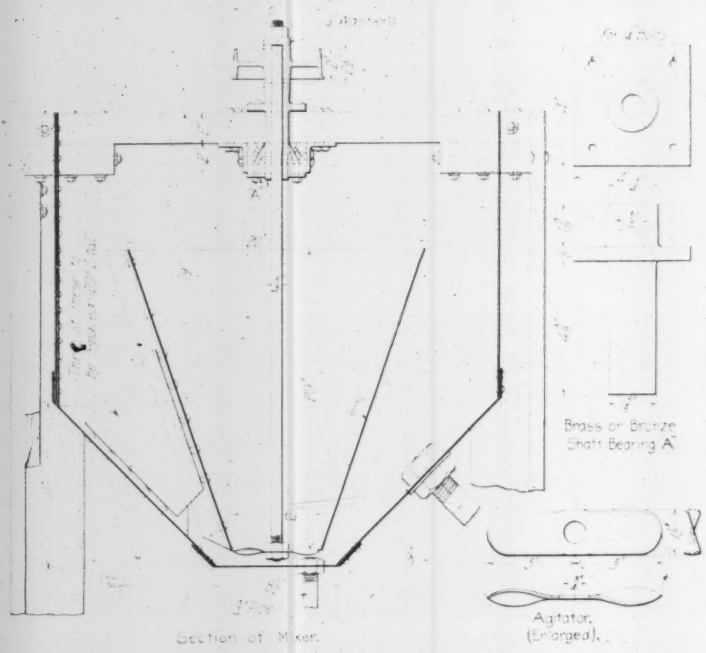


Fig. 1. Original Power-Driven Type, Sheet Iron Tank.

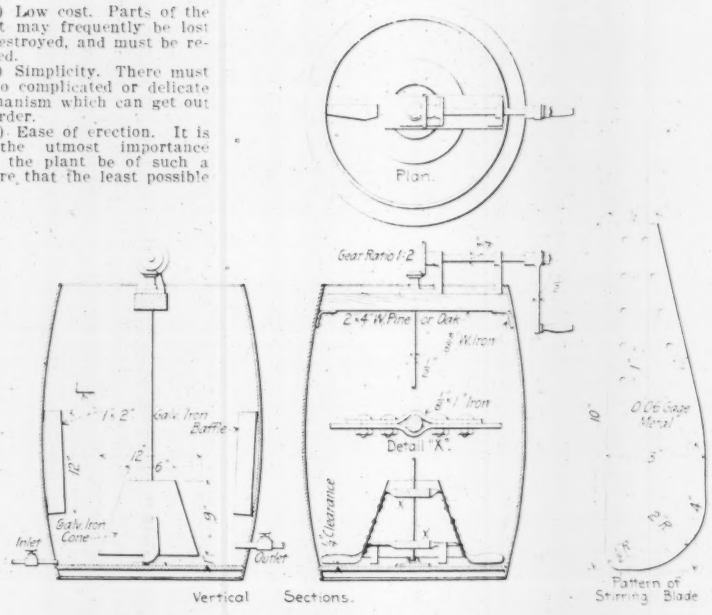


Fig. 2. Later Hand-Driven Type, Oak Barrel.

FIGS. 1 AND 2. ORIGINAL AND LATER MODIFIED TYPE OF MIXER, PORTABLE HYPOCHLORITE PLANT.

*Through a misunderstanding, a large portion of this article was published the latter part of February, 1911, in "The Minnesota Engineer," a quarterly published by the Engineers' Society of the University of Minnesota. The article was, however, written for and at the request of this Journal.—Ed.

†Assistant Engineer, and Chemist and Bacteriologist, respectively, Minnesota State Board of Health, Minneapolis, Minn.

level of the air pipe. The flow of air to the storage barrel will then be shut off and the flow of solution to the regulating keg stopped, thus keeping the surface of the solution in the regulating keg at a constant height.

The flow of solution from the regulating keg is controlled by varying the head upon the 3/16-in. hole in the brass pipe. This is done by the raising or lowering of the pipe, which has previously been calibrated.

Credit is given to Messrs. H. Allison and R. Cowling, Chemists, who first applied the principle of the air-tight barrels, while in charge of the hypochlorite plant at Hibbing, Minn. The application of this principle makes the use of small and portable hypochlorite plants far more satisfactory than by the use of the usual float-valve administering device.

The idea of maintaining a portable emergency hypochlorite plant was originally advanced by Mr. Whittaker. The present design has been developed by Mr. Childs under the general direction of the Director of the Division of Engineering of the State Board of Health, Mr. Bass.

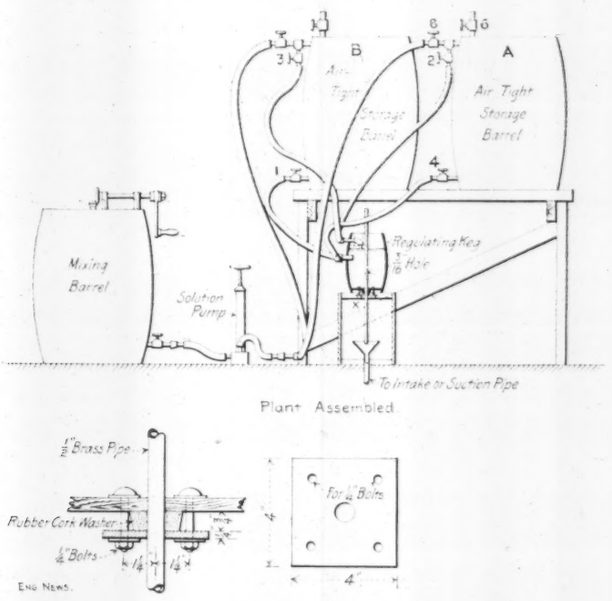


FIG. 3. THE PORTABLE HYPOCHLORITE WATER DISINFECTING PLANT OF THE MINNESOTA STATE BOARD OF HEALTH.

The apparatus, as described above, was constructed for $42, exclusive of labor of assembling parts. In one municipality where this emergency plant was installed it was set up for operation in about two hours.

Permanent Hypochlorite Plants for Small Cities.

With a few changes, such as the substitution of galvanized-iron piping for the rubber hose, and the installation of a power-driven mixer for the hand-driven barrel mixer, the emergency plant described in this article can be readily adapted to use where the municipal water-supply is such that a permanent disinfecting plant is necessary. In fact, there are two such plants in this state at present: One at Crookston, where the State Board of Health has directed the construction of a plant for the Crookston Water Co., the steel mixer described above being installed. One at Brainerd, installed by the city water and light department.

It is better when a mixer of the type shown in Fig. 1 is installed in a permanent plant, to construct the body of the mixer of concrete instead of sheet-iron. All metal parts exposed to the action of the hypochlorite should be kept well painted. Where iron piping is used, crosses with one or two of the openings plugged should be used instead of elbows and Ts. This arrangement allows for easier cleaning in case the piping should become clogged at the bends.

A Case of Failure of Bridge Pier Foundations and the Methods Adopted for Reconstruction.

The entire failure of the foundations supporting a railway bridge pier is a sort of engineering disaster which is fortunately rare. Perhaps the most notable case on record is the disaster which occurred during the erection of a bridge over the St. Lawrence river a dozen years or more ago. More recent notable cases of bridge pier failures have been the destruction of the concrete bridge at Peoria and the sinking of a pier of a concrete bridge at Jacksonville, Fla.

All such disasters are most useful object-lessons to the engineer. We present below an account of a disaster which occurred a few years ago in a railway line in the Northwest. At the time the events occurred we were unable to obtain definite and complete particulars for publication. We are able to do so now with the omission from the record of names and places. The facts, however, are sufficiently instructive to be worth publication:

The bridge, at which the accident occurred, consisted of several plate-girder spans and a draw span of 195 ft., with its rail level 32 ft. above the water. The piers were of stone about 25 ft. high above the water and resting on pile foundations. The river is 25 to 30 ft. deep in the channel, with a fairly rapid current. The river bottom has a depth of 25 ft. of soft silt, underlaid by 30 ft. of soft blue clay, and then 8 to 10 ft. of hard gravel and sand overlying the rock. A thin layer of sand (not over 24 ins. thick) lies between the clay and the gravel. For heavy loads, the piles must rest in the gravel bed, which is hard enough to make driving very difficult and to cause the piles to come to refusal before they reach the rock.

The piles used in the original foundation were of Norway pine, 14 to 20 ins. at the butt, and 60 to 75 ft. long (80 ft. for the center pier). They were driven to water level and cut off at 10½ ft. below (11½ ft. for the center pier). This gave 35 to 55 ft. penetration. On account of the great length of the piles above the gravel bed, a box crib was placed around the piles of each foundation; this was built of 6 × 8-in. timbers close-jointed and framed. When sunk in place, with its top level with the cut-off line of the piles, its lower edge was several feet below the river bottom. The space inside the crib was to be filled with riprap, so that the group of piles would act as a unit in resisting lateral forces. The piles were capped with a grillage of three courses of 12 × 12-in. timbers (four for the center pier); the timbers were laid close in the bottom course and 12 ins. apart in the upper courses. The top of the grillage was 7½ ft. below water line, and upon this the stone masonry was built.

About a month after the completion of the piers, the center of the pivot pier was found to be about 14 ins. out of line, both longitudinally and transversely. This increased slightly in a few days, and levels showed that diagonally opposite points were 3 ins. and 2 ins. low. Steps were taken to arrest the settlement and bring the pier back to its proper position. It was proposed to drive a 50-ft. ring of piles (tied together at the top by wire cables), and then a second ring inside of this, wedged firmly against the first ring. The space inside of the inner ring was to be filled with rip rap. To force the pier back into place, it was proposed to drive piles between the ring and the pier on the side towards which the pier was shifting. When the outer ring of piles was nearly completed (a few weeks later) the pier was found to be 18 ins. low, and the next morning it had disappeared.

Investigation by sounding and by divers showed that the pier had fallen almost inside of its area. Apparently the settlement had been greatly increased by the driving of the ring of piles, possibly through some effect upon the layer of fine sand which lies between the gravel and clay strata. When the settlement had reached a certain point, the foundation apparently gave way suddenly, breaking off the piles at about mid-length and dropping the pier before it could move any great distance out of place.

Doubts were then felt as to the safety of the other piers, and before making attempts to strengthen the foundations by additional piling it was decided to experiment upon the permissible loading for piles. Four piles were driven at about 12 ft. centers and capped with a loading platform. A load of 60 tons (15 tons per pile) was carried for a week without settlement, but an increase of only four tons (making 16 tons per pile) caused a settlement of about ¾-in. per day on one side of the test frame. It was concluded that the ultimate load per pile should not exceed 15 tons, and as the piers still standing were loaded at 12 to 16 tons per pile by dead and live load combined, it was decided to rebuild them.

In rebuilding the center pier, 226 piles were driven, covering an area about twice as great as that of the original foundation. These were cut off 20 ft. below water and capped with a grillage high enough to bring the bottom of the masonry to the old level. The grillage had four courses laid solid, and the remaining courses laid in open arrangement. The entire foundation was stiffened by dumping riprap around the piling sufficient to form a cone reaching down to firm ground and extending up to the base of the grillage. A 100-ft. ring of piles was driven to the bed of the channel (22 ft.), with three bands of 1¼-in. wire cable near the top. Before placing the grillage, the spaces between the bearing piles was packed with rip rap, and finally rip rap was filled inside the pile ring to the level of the tops of the piles. Thus the pier became the center of a rip-rap cylinder which was calculated to relieve the piles of all but vertical forces.

In rebuilding each of the other piers, the masonry and grillage were first removed, and the old piles driven (by a follower) to refusal. An additional row of piles was then driven around the old piles, and all were cut off at 20 ft. below water (instead of 10½ ft.) The new grillage was carried up to the old level (7½ ft. below water) and the pier then rebuilt. Riprap was filled between the bearing piles and afterwards deposited around each pier to form a cone extending to the base of the grillage.

An earlier bridge in the same neighborhood had developed no such trouble as described above. Its pivot pier had much less weight of masonry on double the number of piles (75 to 80 ft. long) driven 10 to 15 ft. deeper so as to be well down into the hard gravel (and cut off at 18 ft.). The load per pile (including live load) was but 33% of that on the pier which failed.

THE REAL OPENING OF THE ALASKA COPPER mines will take place on April 6 when the first ore shipment will leave the famous Bonanza mine over the Copper River & Northwestern Ry. This railway, which was begun in November, 1907, is now just completed between Cordova and Kennicott, a distance of 197 miles. It is the intention of the builders of the road to ultimately extend it to Fairbanks and the Yukon River. It is owned by the Morgan-Guggenheim interests, who also own the Bonanza mines. The ore is to be smelted at Tacoma, Wash., between which port and Cordova two ore-carrying steamers will be put into service about May 1. It is claimed that Alaskan copper can be made at Tacoma for about 6 cts. per lb., compared with 9 to 10 cts. per lb. required to produce Montana, Arizona and Lake Superior copper.

Trimetric Cross-Section Paper.

By ARTHUR SCHULTZE.*

If three edges of a cube which meet at a common vertex are projected orthogonally upon a plane, the projections are called *isometric*, *dimetric*, or *trimetric* according to whether three, two, or none of the resulting projections are equal.

As the isometric projections of the edges of a cube are equal, and the angles formed by them are 60° or multiples thereof, these projections can be based upon a cross-section paper which consists of three sets of equidistant and parallel lines, intersecting each other at angles of 60°. Such isometric paper makes the construction of a great many projections exceedingly simple, but in spite of this simplicity it is not very widely used, chiefly on account of the peculiarity and inferiority of the pictures produced.

The annexed isometric projection of a cube (Fig. 1), for instance, shows several disturbing symmetries; the diagonals coincide with the edges, and figures lying in the diagonal planes cannot be represented. The projection of a regular tetrahedron shown in the same diagram does not convey a clear impression of the solid to be represented.

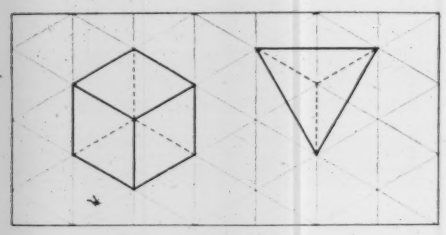


Fig. 1 Isometric Projection.

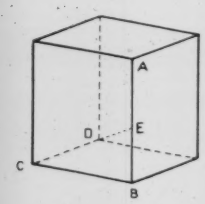


Fig. 2.

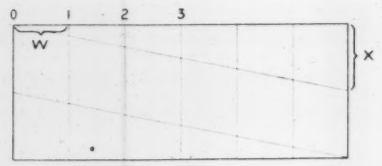


Fig. 4.

To obviate these difficulties the writer has devised a series of trimetric papers, which make trimetric projections as simple as isometric ones, without having their defects.

Theory of Trimetric Paper.

If the entire space were filled with adjacent cubes such that the edges of each were the prolongations of the edges of adjacent cubes, the projection of all these edges upon a plane would represent a system of trimetric lines. In general, however, we would obtain an infinite number of such lines.

To obtain a finite number of lines we have to consider the particular cases in which the projections of the edges coincide in cyclic recurrence with the projections of other edges. In order to discover these special cases we construct the projection $A\ B\ C\ D$ of a cube (Fig. 2), and produce $C\ D$ to meet $A\ B$ at E.

To produce a cyclic coincidence of the vertical edges, $\frac{C\ E}{C\ D}$ must be a rational number, and similarly, it follows from the coincidence of the horizontal edges, that $\frac{A\ B}{E\ B}$ must be rational.

Hence, if m and n denote two rational numbers, preferably small integers, or simple fractions, we have the conditions:

$$C\ E = m\ .\ C\ D$$
$$A\ B = n\ .\ E\ B$$

Let us now consider all lines of the diagram as vectors of the form $a + b\sqrt{-1}$ or $a + b\ i$, then we have:

$$E\ B + B\ C + C\ E = 0.$$

Or, making $A\ B = x$, $B\ C = y$, and $C\ D = z$,

$$\frac{x}{n} + y + m\ z = 0 \qquad (1)$$

According to Gauss' Theorem, the orthogonal projections x, y, and z, of the edges of any cube whose edge $= a$ are connected by the relation:

$$x^2 + y^2 + z^2 = 0 \qquad (2)$$

Making $x = 1$, and solving equations (1) and (2), we obtain:

$$y = -\frac{1}{n\ (1 + m^2)} \pm \frac{m\ i}{n\ (1 + m^2)}\sqrt{m^2\ n^2 + n^2 + 1} \qquad (3)$$

$$z = -\frac{m}{n\ (1 + m)} \pm \frac{i}{n\ (1 + m^2)}\sqrt{m^2\ n^2 + n^2 + 1} \qquad (4)$$

If we draw $C\ H$ perpendicular to $A\ B$ (Fig. 3), then $B\ H$ represents the real part, and $H\ C$ the imaginary part of y. Hence

$$B\ H = \frac{1}{n\ (1 + m^2)} \qquad (5)$$

$$H\ C = \frac{m\sqrt{m^2\ n^2 + n^2 + 1}}{n\ (1 + m^2)} \qquad (6)$$

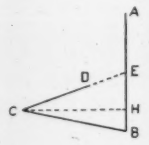


Fig. 3.

If we select for $A\ B$ any convenient unit, then equations (5) and (6) determine the position of C, and since m and n are known numbers, the points E and D are easily found. Hence the projection of the cube $A\ B\ C\ D$ and the entire trimetric system can be constructed.

A trimetric paper constructed in this manner possesses, however, the drawback that the projection of one edge of the cube ($A\ B$ or x) is arbitrarily assumed, and that consequently it is difficult to construct the exact size of the projection of a solid whose dimensions are given. Hence we shall determine the length of $A\ B$ (or x) if the edge of the given cube equals unity.

If x, y, and z are the projections of a cube whose edge equals a, and if $|x|$ $|y|$ and $|z|$ are respectively the absolute values of x, y, and z, then it can be proved that

$$a^2 = \frac{|x|^2 + |y|^2 + |z|^2}{2}.$$

Assuming for x unity, and for y and z the corresponding values equations (3) and (4) we obtain

$$a = \sqrt{\frac{m^2\ n^2 + n^2 + 1}{m^2\ n^2 + n^2}}$$

The values (3), (4), (5), and (6) derived above are based upon a cube whose edge equals a. To obtain the corresponding values for a cube whose edge equals unity, we have to multiply the preceding results by $\frac{1}{a}$ or

$$\sqrt{\frac{m^2\ n^2 + n^2}{m^2\ n^2 + n^2 + 1}}$$

Let us denote the results as follows (Fig. 4):

$w = H\ C$, i. e., the distance between two vertical lines.

$X = x$, i. e., the intercept made on the vertical lines by two successive (nearly) horizontal lines.

$s =$ the number of spaces of width w, for which each of the (nearly) horizontal lines descend a length equal to X.

We obtain then easily:

$$W = \frac{m}{\sqrt{1 + m^2}} \qquad (7)$$

$$X = \sqrt{\frac{m^2\ n^2 + n^2}{m^2\ n^2 + n^2 + 1}} \text{ or approximately:}$$

$$= 1 - \frac{1}{2\ (m^2\ n^2 + n^2 + 1)} \qquad (8)$$

$$s = n\ (1 + m^2) \qquad (9)$$

The formulas (7), (8) and (9) determine the position of the vertical and the nearly horizontal lines, and after these lines are constructed, the value of n determines the oblique lines. Hence the entire trimetric system is determined.

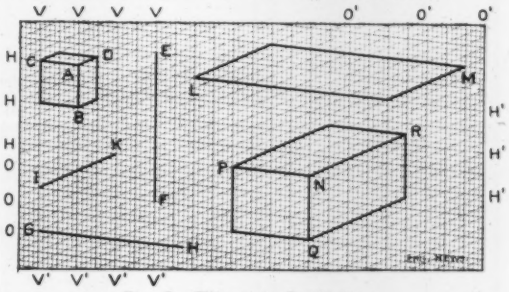


Fig. 5. Trimetric Projection.

If we examine the particular cases which we obtain by the substitution of numerical values for m and n, we find that the case $m = 1$, $n = 1$ leads to isometric projection. The assumption $m = 1$, $n \gtrless 1$, and $m \lessgtr 1$, $n = 1$ lead to dimetric projections which are not well suited for practical work.

The simplest trimetric systems are obtained by substituting (1) $m = 3/2$, $n = 2$; (2) $m = 2$; $n = 2$; (3) $m = 3$, $n = 2$. The following table gives the resulting values upon which the three papers (Nos. 1, 2, 3) are based.

	No. 1	No. 2	No. 3
m	$\frac{3}{2}$	2	3
n	2	2	2
$m\ n$	3	4	6
$m^2\ n^2 + n^2 + 1$	14	21	41
X	$\frac{27}{28}$	$\frac{41}{42}$	$\frac{81}{82}$.
w	$\frac{3}{\sqrt{13}}$	$\frac{2}{\sqrt{5}}$	$\frac{3}{\sqrt{10}}$
s	$\frac{13}{2}$	10	20

Practical Use of Trimetric Paper.

Each of the trimetric papers consists of three sets of parallel lines, viz.: the vertical ones, as $V\ V'$; the lines nearly horizontal (hereafter called horizontal lines), as $H\ H'$, and the oblique lines that ascend from the left to the right as $O\ O'$.

The meaning of these lines is illustrated by the diagram $A\ B\ C\ D$ (Fig. 5), which is the projection of a cube whose edge equals ¼-in. Any line lying on the vertical lines $V\ V'$ is parallel to the edge $A\ B$; any line lying on the horizontal lines $H\ H'$ is parallel to the edge $A\ C$, and any line on the oblique lines $O\ O'$ is parallel to the edge $A\ D$. A comparison of the lengths of such lines with the edges of $A\ B\ C\ D$ enables us to determine the true length of the projected lines.

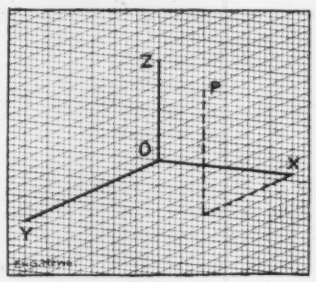


Fig. 6.

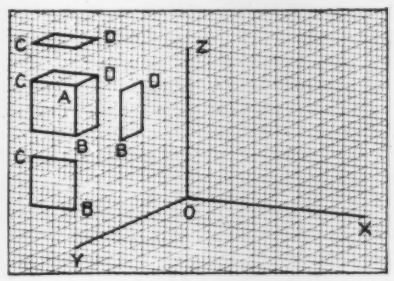


Fig. 7.

*New York University, New York City.

Thus *E F* is parallel to *A B*, and *E F* = 3½ (*A B*), i. e., *E F* represents a line whose length = 3½ × (¼-in.).

Similarly:

G H is parallel to *A C*, and represents 3¾ × (¼-in.).

I K is parallel to *A D*, and represents 4 × (¼-in.).

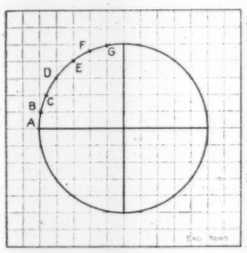


Fig. 8.

Obviously *L M* represents a rectangle 5 units (¼-in) long, and 4 units wide, whose plane is parallel to *A C D*. *N P R Q* represents a rectangular parallelopiped whose dimensions are 2, 1½, and 5 units, each unit being ¼-in.

Similarly *O X*, *O Y*, and *O Z* (Fig. 6) represent three axes, each of which is perpendicular to the other two, and whose lengths are respectively, 4, 6, and 2 units.

Students familiar with coordinate geometry will see that it is quite easy to construct a point whose coordinates are known. Thus *P* represents a point whose coordinates *x*, *y*, *z*, are respectively equal to 3, 4, and 2½ units. It is hence a very simple matter to construct any diagram if the coordinates of all its points are known.

To construct the reference cube *A B C D* it is sufficient to know the following fact:

Each small parallelogram of the diagram is the projection of a square. (This holds true also of the small parallelograms formed by the heavy lines.)

Thus *C B* and *C D* (Fig. 7) represent squares. *B D* which consists of four small parallelograms represents also a square.

It should be noted that the small parallelograms formed by vertical lines (*V V'*) and oblique lines (*O O'*) have only half the dimensions of the squares *C B* and *C D*.

It follows from the preceding statement that:

1. The unit of length (¼-in.) of a line parallel to *O X* or *O Z* is represented by the corresponding side of a parallelogram formed by the heavy lines.

2. The unit of length of a line parallel to *O Y* is represented by the intercept between two consecutive horizontal lines (*H H'*), or by twice the intercept between two consecutive vertical lines (*V V'*).

All annexed rectilinear diagrams are constructed according to the principles of the preceding paragraphs; for curvilinear figures, however, the following facts are essential:

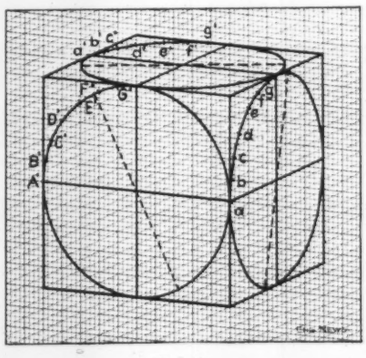


Fig. 9.

1. If all oblique lines (*O O*) were erased the remaining lines would represent a system of squares whose planes are parallel to the front face of the reference cube. The heavy parallelograms thus obtained represent squares whose edges are equal to ¼-in.

The heavy parallelograms are subdivided into smaller parallelograms, and the mode of division is different on different papers. As far as practical work is concerned, this constitutes the only difference between the three papers.

2. If all vertical lines (*V V'*) were omitted the remaining lines would represent a system of squares (¼-in. × ¼-in.) whose planes are parallel to the top face of the reference cube.

3. If all horizontal lines (*H H'*) were omitted the remaining lines would represent a system of squares whose dimensions are only ⅛-in. by ⅛-in., and whose planes are parallel to the lateral face (*A B*) of the reference cube.

To draw any curve in one of the three planes, construct such curve on ordinary cross-section paper and determine the points of intersection of the curve and the lines of the cross-section paper. In any system of parallelograms considered above (which represent a system of squares) determine the corresponding points and join them successively.

Thus to construct the projections of a circle whose radius equals 5, draw on rectangular cross-section paper a circle whose radius is 5, and denote the points of intersection by *A*, *B*, *C*, *D* (Fig. 8).

In each system of squares determine the points corresponding to *A*, *B*, *C*, *D*, . . . and join these points in succession. Thus we obtain the three projections *A' B' C'* . . ., *a b c* . . ., *a' b' c'* . . . (Fig. 9).

Note that the projection of a circle is an ellipse, whose major axis is perpendicular to one of the edges of the reference cube, and equal to the diameter of the circle.

The projection of a curve not lying in these three planes, or a curve of double curvature is constructed by determining successively the three coordinates of a number of points.

The projection of a sphere is a circle whose radius equals the radius of the sphere.

This trimetric paper is published by the O. T. Louis Co., of 59 Fifth Ave., New York City.

Storage Reservoirs for the Control of the Ottawa River, Canada.

A part of the general plan for the Georgian Bay Ship Canal project, which has been agitated in Canada for the past few years, was the improvement of navigation in the Ottawa River by regulation of its flow by means of storage reservoirs. The report on the survey of this canal, issued in 1909* by the Department of Public Works of Canada, made several references to the feasibility of thus controlling the river, and recommended that further investigations and surveys be made.

According to the progress report for the fiscal year of 1909-10, just issued, by Mr. C. R. Coutlee, M. Am. Soc. C. E., Engineer-in-charge, many of these surveys have now been made, and considerable construction work on some of the lower reservoirs is already nearing completion.

Although of primary importance as a part of the proposed Georgian Bay Canal project, these reservoirs are being constructed independently of that plan because of benefits to be derived by present navigation in the river and in Montreal Harbor, by the cities which depend upon the stream for water supply and various industries for water power and in the prevention of flood damage.

The Ottawa River rises 150 miles nearly due north of the city of Ottawa, Ont. It flows westward from its source for a considerable distance; then south for 100 miles and thence turns sharply to the east at Mattawa, where the junction with the proposed Georgian Bay Canal would be made, about 150 miles from Montreal, Que., thus forming three sides of a huge rectangle. The distance from Montreal to the source, as the river flows, is about 700 miles. At Montreal the river has a watershed of 56,000 square miles.

Throughout its length, from its source to the city of Ottawa, it is continually broadening out into long narrow and shallow lakes, which form a series of steps from an elevation at Ottawa of 140 ft. to the Barriere Lakes, 1,100 ft. above sea level and 505 miles, as the river flows, from Ottawa. Between the lakes are falls and rapids, the greatest step being 80 ft. in the 15 miles between Lakes Timiskaming and Quinze.

The discharge of the Ottawa River, just below Ottawa, has been determined by the lockmaster, by measuring the depth of water flowing over the lock-sills, every day since 1844. The yearly mean since 1844 is 55,464 cu. ft. per sec.; the yearly greatest discharge was in 1890, an average daily of 68,584 cu. ft. per sec., and the yearly lowest discharge was in 1877, when the average daily was 35,583 cu. ft. per sec. The mean maximum high discharge for 40 days in 60 years was 158,900 cu. ft. per sec. The seasonal variation in discharge is illustrated by the gagings of 1909, which showed a minimum in January of 25,000 cu. ft. per sec. and a maximum in the latter part of May of 230,000 cu. ft. per sec.

It is proposed, by a series of low dams, to increase the storage capacity of the numerous lakes so that the daily flow of the river throughout the year may be kept as near the 60-year average of 55,000 cu. ft. per sec. as possible. The three first reservoirs of the system, the Timiskaming, the Kipawa and the Quinze-Expanse, are already under construction, and when completed will have a storage capacity of 168,000,000,000 cu. ft., or nearly double the capacity of the reservoirs constructed at the headwaters of the Mississippi River by the United States Government. The cost of these reservoirs, including the construction of four dams, land damages and surveys, is estimated at $728,000, or some $500,000 less than has already been spent by the United States on the Mississippi reservoirs.

These dams will all be permanent concrete structures with stop-log type of sluiceways,

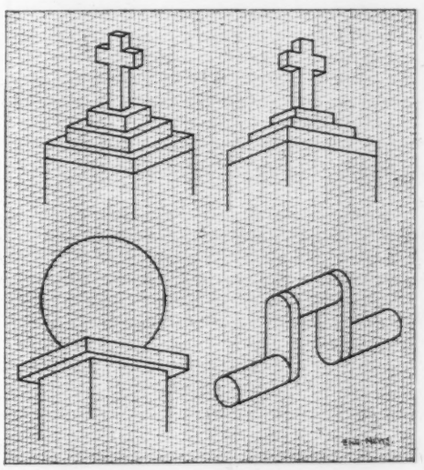


Fig. 10. Examples of Trimetric Sketches.

which is well adapted to the Ottawa River conditions. The policy of building other reserve dams of concrete will be followed excepting in such cases where it will be impossible to transport cement to the work.

The dam at Lake Timiskaming was built in 1905 as a wooden structure, but is now being rebuilt of concrete. This dam raises the lake level 8 ft. At Lake Kipawa one dam is already completed and a second under way, which when completed will raise the water about 10 ft. above its present level. At Lakes Quinze and Expanse, the largest of the dams will be built at a cost of $300,000. This dam will raise the level of the lakes about 10 ft. All of these reservoirs are approximately the same size and are designed to have a storage of 2,000 square-mile feet, with a maximum depth of 20 ft.

Should this reservoir system be ultimately carried back to Grand Victoria Lake, which is about half-way from Lake Quinze to the source of the river, an elevation of over 15 ft. in the water level here, would send the overflow north over the dividing ridge and into Hudson Bay, thus avoiding the gorging of the Ottawa River at times of great floods, by sending elsewhere the surplus which the reservoirs could not care for.

The country about these lakes is still in a great measure virgin land, and little explored. A railway line touches the shores of Lake Timiskaming, but the only entrance to the other lakes is by the river and by use of frequent portages. The country is still 95% heavily wooded with spruce and pine and logging is the chief, and in many cases, the only industry. One of the problems in the design, construction and operation of the dams is the handling of thousands of these logs.

*Abstracted in Eng. News, Feb. 23, 1909.

An Argument for Permanent Construction.

By R. W. WETHERILL.*

Savings never pay dividends; they are paid on wise investments.

There are a lot of people who think that if two machines at a thousand dollars apiece can be made to last as long as one at twenty-one hundred, the two are more profitable than the one, even though the owners are forced to spend in making the cheap ones work a part of the time that would otherwise be spent in getting business to keep the higher priced machine busy earning dividends. This condition exists all round us. Some housekeepers buy cheap furnishings and fixtures, and then spend time on repairs and in worrying about replacement. Some engineers erect cheap structures and spend time in repairing and replacing, instead of planning how their companies can earn (not save) more dividends. This is one very important item too frequently omitted in computing the comparative annual costs of projected installations of all kinds.

One frequently hears from men occupying high positions in the management of engineering and constructive enterprises that permanent construction pays only when the maintenance, the interest on the investment and the depreciation or replacement charges show it to be profitable, as compared with the same charges on less permanent construction. When the management finds that with all these expenses considered, including replacement at certain assumed intervals, a new plant of any kind is going to cost less money per year if built in a manner and of materials that do not make for permanency, that is usually the way it is built. Sooner or later, after placing the plant in service the maintenance charges begin to come in, but the owners are satisfied if they can figure out that the interest on the increased investment, that would have been required for the more permanent construction, would run the annual cost of the plant to a higher figure than for the installation costing less in the interest, maintenance and depreciation charges.

Let us go a step farther than this. Assume that the money is available to pay for what is shown by figures and reasonable judgment to be, not the investment that will make the most money, but the investment that will permit the company to make the most money. There is quite a difference in the light by which two men toil where the results of their thoughts are so widely diverging as are the meanings of these two ways of stating what is intended to be the same thought.

We all know the value of automatic machinery in a factory as compared with that which is not automatic, hence our factories are filled with automatic machines. Likewise we all know the value of a man capable of managing a business as compared with a more or less inefficient workman. The former in most cases needs starting and sometimes something to start on. The latter needs both these and also needs somebody to restart him and to keep finding a supply of the necessary something to start on. You throw out the machine that is not automatic and replace it with one that will at least help feed itself and that will restart itself far and away beyond the apparent limits of some human beings. The only reason you do not discard the non-automatic man is because the supply of good men is very limited and accordingly high-priced. Assistants should be selected, whether men or machines, very largely according to the ability they have to relieve the administrative officials of detail attentions which too easily grow in numbers to very awkward proportions, and interfere with the giving of proper attention of real money-making power of the company, present and future.

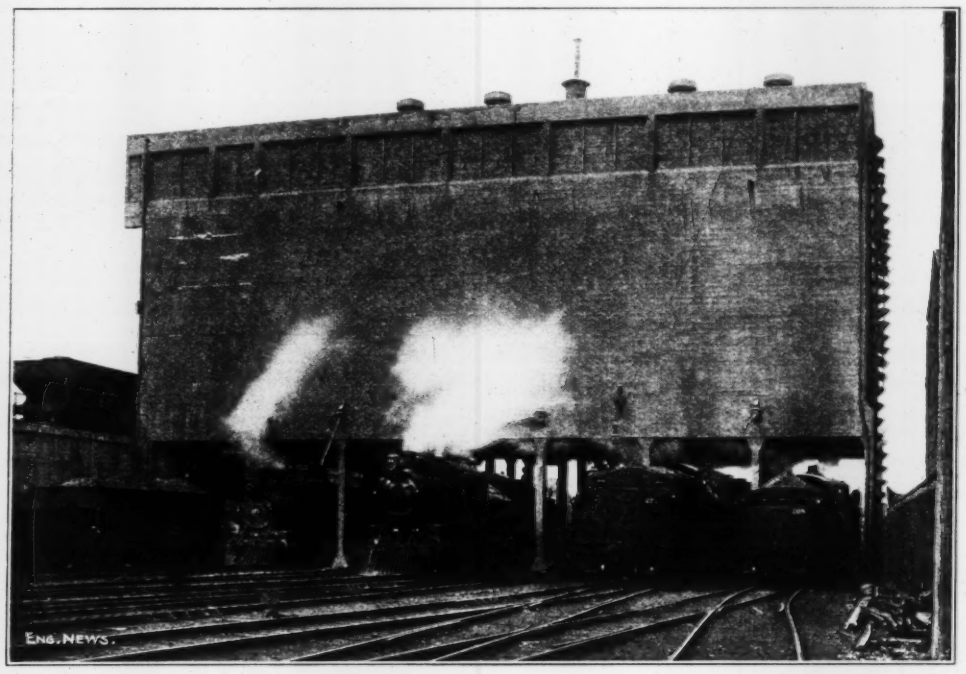
When a constructive engineer advises his clients or employers to build in a temporary way because comparative insurance, maintenance and depreciation charges show it to be economical, he is advising them to install an old-style machine, to employ an inefficient assistant, one that will need more of their attention than should be necessary to keep them earning dividends. In this the engineer has lost sight of a very important item, that of his employers' time. He is treating it too much as merchandise of which the supply is unlimited. Where this method is practiced and the plant grows and expands, the owners soon become burdened with a lot of details requiring time that might just as well and should be given up to increasing the business and improving the methods employed in handling the present business. On the one hand where they build with temporary structures, their limit as producers is soon reached, the effort is overcome by the friction of the machine, a line beyond which they cannot go, at least until perpetual motion is solved. On the other hand where they build permanently, so that an installation once completed will require much less future attention and the replacement of which will be automatic, metaphorically speaking, the limit of production will be much higher. The friction in the machine in regular operation does not overtake the effort put into it nearly so soon, with the general result that the entire organization is capable of taking the time for getting more business.

As a boy the writer knew a contractor of rather contracted vision, who had a steam roller with a leaky boiler. It leaked so badly that between pumping more water into it and shoveling more coal on the fire, bringing the steam down with each operation, it was nearly time to stop for lunch when he finally got up enough steam to roll the road he was building. Some plants in operation are very like this steam roller. It takes them longer to begin to make money than they have time left to make it. Some of our engineers and corporation managers have learned this lesson and many cases might be cited as instances where men are practicing along the more profitable course. There are more doing the other thing, however, a large number of whom it is sad to say will find their mistake only when the friction of the organization overtakes the moving effort. Some attempt to wriggle out by turning a lot of their details over to less capable assistants, but as we all know real ability is scarce and comes high.

A trip through the coal fields would show many instances where men have found their mistake and are to-day erecting at the mines, structures for the preparation and shipping of coal, that will be in good condition, with small annual maintenance costs, a good many years hence. These structures are replacing plants built ten or fifteen years ago, and the real brains of the various concerns so building are now consuming a substantial part of their efforts in overcoming the loss due to misplacing energy a few years back. These managers under various names and titles, are busy men and only pause in their work of accelerating dividends when there is real cause, and from the general methods of construction in a number of plants now under way and projected it is evident that some of them do not propose to continue spending their valuable and very limited time in standing by an old-style machine to keep it running when an automatic one can be had that will run itself for the most part, or what is more important, permit the operator to manipulate many times the number of machines. This condition is the real goal, the goal worth planning for.

At our mines, in our factories, on our railroads and in our shipping and docking facilities, and in fact in every line of business to-day where construction enters, from the administrative office in Wall St. to a coal tipple at the mine, this tendency is manifest. Those who are not in line will sooner or later find themselves running a treadmill, with their limit fixed by its automatic efficiency (or lack of it), which is determined by the character of construction.

*Superintendent of Construction, The J. M. Dodge Co., Philadelphia, Pa.



A NEW REINFORCED-CONCRETE COAL AND ASHES POCKET.

[Placed in commission on Jan. 1, 1911. This plant of large capacity and elaborate equipment is built to withstand the attacking agents that usually affect so disastrously pockets of steel or wood construction. It is the outcome of a desire on the part of railroad engineers to build with materials of lasting qualities and in a manner to require the least attention in the years to come.]

AN ELECTRIC DAMP DETECTOR was described by Mr. G. Ralph in a recent paper before the Newcastle Section of the Institution of Electrical Engineers (British) and abstracted in London "Electrician," March 3. The basic principle of the apparatus is the catalytic rise of temperature of platinum in the presence of hydrogen or a hydrocarbon like "fire damp" or methane (CH_4). The detector carries two thermostatic springs, of two dissimilar metals (like brass and steel), fastened at one end and with their free ends slightly overlapping. Under one spring is a coil of pure platinum and under the other a coil of non-catalytic metal. These coils are connected in series, and in series with a small incandescent lamp. Sufficient current flows to keep the platinum red, at which temperature its sensitiveness to catalytic action is increased. With increase of temperature under normal conditions both bend alike and do not make contact with each other at their free ends. If fire damp be present in sufficient quantities the platinum coil heats more than the other and the springs come in contact. This closes an alarm or cut-out circuit.

A mixture of less than 6% of fire damp is not explosive except with coal dust present, when 2% is dangerous. This detector is sensitive to 2% or over. With a gradual accumulation of gas the detector will operate in about seven seconds after reaching 2% and, with a sudden inrush of gas, in about seven seconds after reaching 6% of gas.

Photography for the Engineer.

By STEWART L. JEFFREY.*

To one experienced in the art of photography, what the writer has herein set down will be neither novel nor especially helpful. But experience, in examining a large number of prints made from negatives taken by engineers in connection with several important projects, shows that no apology for these observations is needed. These prints have showed a general lack of ability on the part of these professional men to accentuate the salient features of the composition together with a slovenly disregard for the minute detail so necessary to make photographs of this kind valuable, and a pitiful lack of knowledge of some of the simplest features of technique and manipulation. These engineers seem uniformly addicted to the use of the "3a Kodak" and it was to point out the inefficiency of instruments of this class for such work and to cause some, perhaps, to investigate the simple and interesting details of photographic processes that have prompted this writing.

The value of a camera to an engineer or contractor depends on his ability to use it. Photography must be considered very difficult or as taking a great deal of time, for there are many hundreds of persons owning cameras who have seldom or never done anything more than make exposures. The convenience of the professional photographer who does developing and printing for novices has been a pitfall to many and it is possibly for this reason, as much as for any other, that these novices go on repeating the same mistakes and never make any real progress in technique.

There is nothing that will so quickly teach a man to properly expose a negative and to discover his own errors, as to make a practice of doing his own developing. There is nothing difficult about the development of plates or films. It is so simple that it seems trite to describe the processes. In each package as sent out by the makers there is a formula for the development with directions for use. This is the best formula to follow, but very satisfactory results can be obtained by using any of the good developing powders which will come all weighed out in small glass tubes and require only to be dissolved in water.

Development requires only three trays, a dark room (a closet or a bedroom at night) a source of light, having a red, or orange and red, shade, and two solutions, one of developer, the other of sodium hyposulphite ("hypo"). Into the first tray is poured the developer, into the second, water, into the third, the hypo. The negative should be dipped in water first to insure an even action of the developer to which it is transferred when wet. It is difficult to give a rule as to when it is quite developed, but it is safe to assume that when the image begins to appear on the back, or glass side, of the plate that the development has brought out all there is to bring out in the negative. Good printing depth is secured when the shadow of a finger held against the plate and about 8 to 10 ins. from an ordinary dark room lamp cannot be seen through the darkest part of the negative. The negative is then rinsed in water and transferred to the hypo. In a few minutes it may be taken out into the light and examined. When the white film has disappeared from the back the negative has been fixed and it should then be washed in water to remove the hypo and then allowed to dry—the drying should be rapid. The development of a properly exposed negative in the usual metol-hydrokinone formulas takes about two minutes, fixation should be complete in from five to eight minutes and negatives should be washed for from 30 minutes to an hour.

As to the cost of developing, a tube of developer that will make 8 oz. of solution may be purchased for 5 cts. and will easily develop 24 plates of a size not larger than 4¼ × 6½ ins. The solution will keep a long time if stored in a tightly corked bottle. Hyposulphite of soda costs from 3 to 5 cts. a pound and this quantity will make 2 qts. of solution. All the necessary apparatus may be purchased for less than $1, including three trays, a lamp and a rack for drying the glass plates. The bulk is so small that it is feasible for an engineer on a reconnaissance survey to take with him everything necessary to finish his negatives the day they are exposed.

Considering the importance of the camera in the engineering field it is strange that so many of the profession are willing to use very inferior instruments and to accept, practically without question, the claims of one or two large manufacturers who cater to the amateur and novice almost exclusively.

The amount of money that is annually wasted in outfits that are nearly worthless is almost incalculable and the number of persons who purchase the instruments, with practically no conception of their own requirements or what constitutes desirability, is beyond calculation.

We are all familiar with the enthusiastic novice who purchases a small folding camera, using films, and then adds to his equipment an expensive rapid anastigmatic lens, with the possibilities and limitations of which he is absolutely ignorant, and who is naturally dissatisfied with his results. The effect is that thousands of such instruments are on sale at the second-hand dealers at greatly reduced prices.

It is difficult to understand why engineers are willing to invest an amount of money which would obtain an efficient outfit, without first acquiring enough knowledge of photographic technique to enable them to choose their instrument intelligently.

Cameras are made in many styles, the simplest of which is the fixed-focus. In instruments of this type the lens is ground for a very short hyperfocal distance, usually 8 to 15 ft. This type is usually found in the cheaper grades of cameras and they are uniformly small, never larger than 4 × 5 ins. plate. The reason for this is that with the increased length of focus needed to cover larger plates it becomes impossible to grind a lens for so short a hyperfocal distance and have enough speed to permit "snap-shots." The objection to cameras of this class is that critical definition is impossible, and except in the smaller sizes general definition is not even good. This objection has been partly overcome, in an instrument recently introduced, by a combination of parts which are much better than are usually found in a camera of this type, but the effort to secure good definition has resulted in an instrument too small to be of any real value for the serious work of an engineer.

The type of camera in most general use is the folding type designed for the use of roll films. They are usually equipped with rectilinear lenses of fair quality and are focussed by sliding the front out to a point indicated on a scale set in the bed of the instrument. They are designed primarily for use without tripod and are made for all sizes of negative up to and including 5 × 7 ins. The angle of view embraced is judged by looking into a small finder attached at or near the front of the instrument. Such outfits are open to very weighty objections; the lenses furnished are rarely adapted to serious work and to fit them with an anastigmat is quite useless, as it is impossible to be sure that they are in exact focus at the time the exposure is made. Most of them are open to the further objection that the bellows is too short to permit the use of the rear combination of a convertible lens.

A camera which has come rapidly into prominence within the last few years is the reflecting type. In these the image is seen the full size of the plate and, in some models, in the position it will occupy in the finished negative. These instruments are designed for the photography of rapidly moving objects and for this purpose are distinctly valuable. They will answer very well for almost any class of photographic work, but their necessary weight and bulk do not commend them to the engineer.

A most useful type of instrument is the view camera. Here the size is unlimited, the angle of view embraced is clearly seen, and focussing can be accurately done on the ground glass. They cannot be readily used as hand cameras, however, a fact which necessitates carrying heavy and bulky equipment.

Omitting some highly specialized types of cameras designed for high-speed work, copying, studio use, etc., we come to an instrument which merits very close attention—a folding camera, adapted for use either with or without tripod, allowing direct focussing on the ground glass, using plates or films interchangeably, and having considerable bellows extension. This type should be further developed for it is in this type only that an efficient all-around instrument can be obtained.

Lenses are of several types, but the only one we need to consider for our purposes is the anastigmat. These are the most modern development of the opticians and are characterized by freedom from astigmatism, coma and distortion, and by great flatness of field, nearly perfect chromatic correction and speed.

Astigmatism is that fault in a lens which renders impossible the equally sharp definition of horizontal and vertical lines. This refers only to the rays of light which enter the lens at an angle and are refracted to the margin of the plate. It is shown in rectilinear lenses in a falling off in definition towards the margin of the plate.

Coma is that fault in a lens which causes it to produce gray flat negatives the finer contrasts and definition being lost in stray light.

Distortion is the inability of a lens to produce the straight lines of the object in the image and is shown in some lenses by a bulging out at the center of the image of lines which should be parallel.

A lens is convertible when the separate combinations, front and rear, can be used independently of each other. This gives the operator a choice of several focal lengths permitting him to make images of various size of the same objects from the same point of view, the size of the image being in direct proportion to the focal length.

The speed of a lens depends on the amount of light it passes. It is measured by the relation of its aperture to its focal length, e. g., the symbol $f/8$ means that the aperture is ⅛ the focal length. There are other systems of lens marking in use, all are based on this relationship. Among them is the uniform system, used by some makers because the necessary exposure is directly proportional to the numerical value of the stop used, i. e., U. S. No. 16 requires four times the exposure of U. S. No. 4.

Depth of focus (or field) is the range within which a lens will produce images of near and distant objects in equally sharp focus. This depends upon the relationship between the aperture and the focal length. It decreases as the aperture and focal length increase. Of two lenses having the same aperture, but unequal focal lengths, the one having the shorter focal length will have the greater depth of focus. Of two lenses having the same focal lengths but of unequal aperture the one having the smaller aperture (the slower lens) will have the greatest depth. This explains why it is impossible to get great depth of focus in the very fast lenses except in the smaller sizes.

The depth of focus for any lens, for any distance, can be determined by means of the following formulas. The focus (usually termed the "equivalent focus") or the focal length of a lens is the distance between its optical center and the sharp image of the sun, moon or any object at a great distance. The size of the image is directly proportional to the focal length when the distance to the object is constant. The relationship between the size of the object, size of the image and the focal length of the lens projecting that image is expressed in the following equation: n representing the scale which the image bears to the object:

$$\text{Distance of object to center of lens} = (n + 1) \times \text{focus.}$$

$$\text{Distance of image to center of lens} = \frac{(n + 1)\ \text{focus}}{n}$$

The hyperfocal length of a lens is the mini-

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mum distance at which a lens will give good definition, expressed in terms of the circle of diffusion, when focussed for maximum definition at infinity.

The hyperfocal length $F_h = \dfrac{f^2}{d \times \text{relative aperture}}$

where d = diameter of the circle of diffusion. The allowable diameter of this circle of diffusion is usually taken, for contact printing, at 1/100-in., so that commonly,

$$F_h = \frac{f^2 \times 100}{\text{relative aperture}}.$$

To determine the depth of focus for any distance D for any stop (relative aperture) used:

(*a*) $\dfrac{F_h \times D}{F_h - D}$ = maximum distance of sharpness.

(*b*) $\dfrac{F_h \times D}{F_h + D}$ = minimum distance of sharpness.

(*a*) — (*b*) = depth of focus.

To compare two commonly used lens speeds, *f*/6.8 and *f*/8, assume two lenses of equal focal length, 6 ins., diameter of allowed circle of diffusion 1/100-in. with the first aperture.

$$F_h = \frac{36 \times 100}{6.8} = 530.8 \text{ ins.}$$

When focused on an object 20 ft. (240 ins.) distant:

$\dfrac{530.8 \times 240}{530.8 - 240} = 437$ ins. = 36.4 ft. = Maximum distance of sharpness.

$\dfrac{530.8 \times 240}{530.8 + 240} = 165.2$ ins. = 13.7 ft. = Minimum distance of sharpness.

36.4 — 13.7 = 22.7. ft. = Depth of focus at 20 ft.

For the relative aperture *f*/8,

$$F_h = \frac{36 \times 100}{8} = 450 \text{ ins.}$$

When focussed at an object 240 ins. away,

$\dfrac{450 \times 240}{450 - 240} = 514.2$ ins. = 42.8 ft. = Maximum.

$\dfrac{450 \times 240}{450 + 240} = 156.5$ ins. = 13.04 ft. = Minimum.

42.8 — 13.04 = 29.76 ft. = Depth of focus at 20 ft.

If very much more accurate definition than this is required and the diameter of the circle of diffusion be considered as 1/1000-in., using the same formulas we find that at 20 ft. the aperture, *f*/8, has a depth of focus of 2.14 ft., while the aperture, *f*/6.8, has a depth of focus of only 1.08 ft.

By means of these formulas we can ascertain exactly the limitations of any lens so far as depth of focus at any distance is concerned. A lens reaches its maximum depth of focus when focussed at its F_h, the depth then extending from $\frac{1}{2} F_h$ to infinity.

The intelligent choice of a lens depends on this feature as well as on the speed and length of focus in comparison to the limitations of the bellows. The choice of a lens depends on what it is wanted for. Excessive speed is not desired by the engineer, as what would be sacrificed in depth of focus would be a serious drawback. It must also be remembered that the indicated speeds are the same in all lenses; a lens whose maximum aperture is *f*/4 when stopped to *f*/16 is of the same speed as a lens whose maximum aperture is *f*/16.

The question of shutters is one of considerable importance to the engineer-photographer. The most efficient shutter is the focal-plane type, but it is neither necessary nor entirely desirable, unless the instrument is to be used to picture rapidly moving objects. The roller-blind shutter, similar in action to the focal-plane, is thoroughly efficient, but it is bulky and most types open the lens aperture while being set. These are not as good for our purposes as the better grades of between-the-lens shutters. A between-lens type, often supplied on folding cameras, has three indicated speeds, instantaneous, bulb and time; these are not well adapted to anastigmatic lenses, but there are several excellent shutters, of this type, made here and abroad which combine the necessary accuracy in exposure, simplicity and strength of design, and which add no bulk to the camera as they take up the space otherwise occupied by the barrel of the lens.

What the engineer and contractor needs is a well-made, portable, hand and stand camera, using interchangeably plates and films of a size approximating 4¼ × 6½ ins., and having a revolving back. The optical equipment should include a first-class controvertible anastigmatic lens of a speed of *f*/8 or *f*/6.8 at most, with a thoroughly good between-the-lens shutter, allowing automatic exposures from 1 to 1/150 second duration at least, and non-automatic or time exposures. The focussing should be done on the ground glass and there should be a focussing hood to overcome the disadvantages of a separate cloth. The bellows must be long enough to permit the use of the single combinations of the lens separately and also to permit the use of a telephoto lens when a large image of a distant object is desired. The instrument must be absolutely rigid at all extensions.

Such an instrument, free from all unnecessary complications, and strong enough to withstand

Fig. 1. Too Great An Angle Embraced.

Fig. 2. Taken From the Same Point as Fig. 1, But With Rear Lens Combination Alone.

FIGS. 1 AND 2.

Fig. 3. Underexposed; Machine Details Lost on Account of Thinness of Negative in the Shadows.

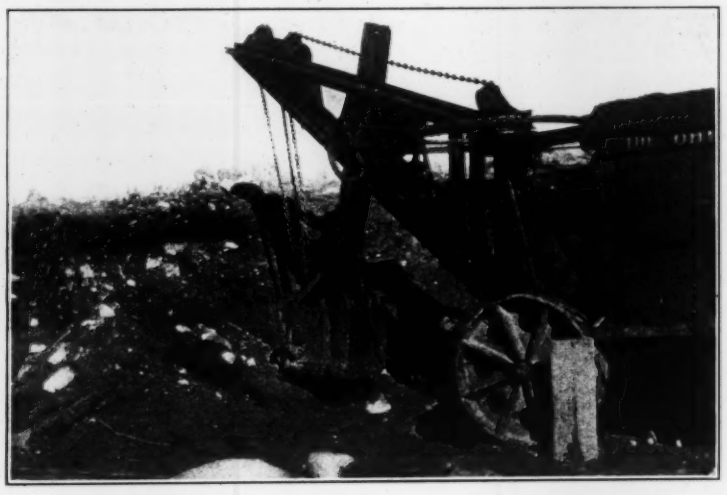


Fig. 4. Proper Exposure to Bring Out Details of Machine.

FIGS. 3 AND 4. TWO PHOTOGRAPHS OF A STEAM SHOVEL WORKING AGAINST A BANK.

severe transportation, would require only a brief experience and ordinary intelligence on the part of the operator to produce uniformly good results.

Such an outfit could be made and marketed at a price which would bring it within the means of all, and with it one could produce contact prints large enough to answer most purposes, thereby obviating the necessity for enlarging. The box on the market nearest to our ideal would cost about $25 or $30. A thoroughly good, though perhaps a less ornamental one, could be produced for $10 to $15 less if the makers should find that a demand arose. The price of lenses varies, say from the Ross Homocentric, series IV. *f*/8, at $36.50 and series V. *f*/6.8, at $40, through the Plastigmat, *f*/6.8, at $48, the Goerz Dagor, series III., *f*/6.8 at $51.50, to the Zeiss Protar, series VIIa, *f*/7.7, at $70. These prices refer to lenses capable of covering a plate 4¼ × 6½ ins. The suitable shutters may be for example the Koilos and Goerz Tenax at $14 or the Goerz sector at $20.

The writer has stated that experience with the work of many engineers has shown a general lack of ability to accentuate salient features of composition and a disregard for necessary detail. It is not easy to show the tyro the evil of his ways in these matters by mere printed statements and possibly the following concluding remarks may be deemed somewhat in the same class as books purporting to teach the art of swimming.

Briefly, one should have clearly in mind the reason for taking a picture. If there is, as is usually the case, only one important element in the view, the camera should be placed at such distance that the object will occupy the greater part of the plate and only enough of the surrounding objects should be included in the view as to enable one to orient the picture. Figs. 1 and 2 will illustrate this point.

As pictures taken by engineers, or by men in their employ, have to do very often with machinery or the application of machinery the photographer must learn to expose in such degree as to fully bring out shadow details. It is a common experience to see a picture where the salient feature, say a shovel working in a bank, is in the foreground and is almost indistinguishable while the background, wholly unimportant, is very well brought out. Two or three times the exposure given would have given the foreground life and line and would have made the print of some value. A comparison of Figs. 3 and 4 shows this.

This may seem like mere technique, and indeed it is, but it deals with the two defects most common in photographs of this kind—(1) under exposure and (2) using too great an angle of view—crowding the plate with too many unimportant elements.

Artistic composition is something which does not necessarily enter into commercial work nor can it be defined within the limits of a few sentences, but it has for its watchword, simplicity, and this should be taken as the motto of the engineer and the photographer employed on engineering work. The writer has before him a picture by the photographer for a large railroad system; the picture was taken to show the method employed to support track while the grade was being elevated. It is a view of a railroad bridge carrying two tracks over two tracks on a lower level while the grade of the upper level is being raised without disturbing traffic on either level. The picture shows a temporary timber trestle supporting the old upper level while two plate-girder spans are being placed. The view was taken from the lower level and from such a point that the two new spans appear to be immediately above the old upper level while as a matter of fact the new bridge is at a considerable distance to one side. Had the view been taken from the upper level, which could have been done as shown by the existence of a wing wall, the temporary trestle work could have been shown quite as well if not to greater advantage, while the perspective would not appear to be distorted.

Another point I might mention is that in depicting ashlar masonry or concrete, particularly where there is an overhanging coping, the point of view should be chosen so that the rays of light from the sun and the prolongation of the lens axis both form an opposing obtuse angle on the surface of the wall.

In this position the shadows accentuate the structure of the wall and give depth to the coping or other ornamentation.

In photographing plant, it is desirable to get as light a background as possible in order to bring the details of the machinery clearly into view. From Figs. 3 and 4 the benefit that might have been secured, with a lighter background, may be understood.

Portable Storage Batteries as Applied to Automatic Signals on the Harriman Lines.*

By A. H. McKEEN.†

The application of portable storage batteries to signal circuits on the Harriman Lines began in 1890 on the Western Division of the Southern Pacific Railway, under the direction of Mr. W. W. Slater, then Master of Signals. At the time there were no motor-operated signals on the Southern Pacific Lines and the use of portable storage batteries was confined to operating highway crossing bells and indicator and locking circuits at hydro-pneumatic interlocking plants. The type of battery then in use was crude, heavy and of generous dimensions for its capacity. No charging plants were in service, and it was necessary to charge the batteries on an arc circuit, carrying approximately 2,000 volts.

It was found that a considerable saving was effected through the use of these portable storage cells, as compared with the cost of operating the circuits with primary and gravity cells. With a view of extending the use of storage cells to several installations of single track electric automatic block signals that were contemplated, tests were carried on for several years with various types of portable storage batteries on the market. The results of these tests were so satisfactory that in 1899 and 1901, when these several installations of automatic signals were completed, the experimental stage had been passed and portable storage cells were decided on as being the least expensive and most satisfactory source of energy for operating the motor circuits.

Gravity batteries were used for the line and track circuits, although later on, the gravity line batteries were dispensed with and the storage battery served the double purpose of operating both line and motor circuits. Each of the above-mentioned signal installations consisted of approximately 20 miles single track. At the foremen's headquarters of each installation a charging outfit was installed, consisting of a 2-HP. gasoline engine, belted to a 1-KW. generator. The foreman attended to the work of charging and inspecting the batteries, and distributing them to the nearest stations on local passenger trains. There they were taken to the battery locations by the maintainer on a velocipede or motor car; the discharged batteries being returned to the charging plant in the same manner. The operating officers of the lines comprising the Harriman System recognized the advantages of automatic signaling as a means of facilitating and safeguarding traffic, with the result that each year, additional mileage of automatic signals was authorized. The amount of such mileage usually was the maximum that could be installed by the signal departments of the various lines during the year. With the close of 1910 the entire main line of the Union Pacific and Southern Pacific from Omaha, Neb., to Oakland, Cal., a distance of 1,779 miles, was thus protected for the entire distance, except for about 100 miles over the Sierra Nevada mountains, where the electric train staff is in service. The main lines of the Oregon Short Line and the Oregon-Washington Ry. & Navigation Co. between Granger, Wyo., and Portland, Ore., are protected in a like manner, for the entire distance of 941 miles.

The main lines of the Southern Pacific from Portland, Ore., to El Paso, Tex., and from El Paso to New Orleans, a total of 3,226 miles, are protected with automatic signals for a distance of 1,938 miles, or 60% of the entire distance; and it is calculated that the remaining 1,288 miles will be completely signaled within two years. The total mileage of road protected by automatic signals on the entire system, on Dec. 31, 1910, was 4,719 miles of single track, and 703 miles of double track, or a total of 6,125 miles of track. On this mileage there are 12,050 automatic signal blades, practically all of which are operated by portable storage battery. There are in all 9,026 battery locations with a total of 48,516 cells in service, of which 12,412 cells, or 25%, are extra cells used for changing.

The methods of transportation to and from the charging plants vary with local conditions. On portions of the line where local passenger service is available, the batteries are loaded into the baggage car and distributed at each station by the batteryman, who accompanies the train. From the stations they are taken to the various battery locations by the maintainer on a velocipede or motor car, the discharged batteries being returned in the same manner to the station, where they are picked up by the batteryman and brought back to the charging plant on the return train in the evening.

On other sections of the line the batteries are loaded into a specially arranged battery car and handled on local freight trains, stops being made at each battery location, where the batteries are changed by the batteryman and the maintainer on that district. The car containing the discharged batteries is sent back to the charging plant on the first freight train.

Another arrangement consists of a charging plant built in a box car, which car is moved on the daily way freight and is set out at each alternate station. The batteries are changed out in each direction from the station by the maintainer. This charging car is fitted up in three compartments; at one end are the gasoline engine, generator, switchboard, and cooling tank. A large tank holding sufficient gasoline for one month's supply is suspended under the body of the car. The center part of the car is used as a battery room and is suitably fitted up with a battery bench, lead-lined sink and a large water tank for battery washing purposes. The other end of the car is arranged as living quarters for the batteryman. The car is equipped with heavy draft gear in order to avoid any damage due to rough handling while in transit.

During the three years that this portable arrangement has been in service, it has given the best of results, handling on one district 832 cells monthly on a territory of 150 miles of single track signals. An important advantage in this method is that on the 150-mile district referred to, only 80 extra cells are required for changing out purposes; this being only 10% of the total number of cells in service on the district.

On the Harriman Lines there are 52 charging plants, each of which (except the portable plants) is located at the headquarters of the assistant supervisor, where a shop building is provided, and part of this shop building is used to house the charging machinery. Hence no special building is necessary. The average territory covered by each plant is 104 miles. Wherever current can be obtained from local power companies, a mercury arc rectifier or motor generator set is installed and at other locations where electric power is not available, a gasoline engine and generator charging outfit is used. Each charging plant is in charge of a special batteryman, whose duties consist of charging, inspecting and cleaning the batteries and assisting the maintainers in changing out the cells on their districts.

All cells are returned to the plant monthly and are thoroughly inspected and cleaned before being put on the charging circuit. A record is kept (in a book) of the voltage, specific gravity and condition of each cell on arrival at the plant and each cell is examined for short circuits or other faults; the hard rubber covers and connectors are cleaned and sediment removed if necessary. Once a year the old electrolyte is replaced with new in order to discard all impurities held in solution.

In the case of stationary batteries it is the usual practice to give an overcharge several times a month, the overcharge having the effect of driving the sulphate out of the plates and keeping them in a healthy condition. Portable cells which are charged once a month only, are subject to considerable sulphating and therefore require a long charge to bring them up to capacity. It is the practice to continue the charge for two or three hours after the voltage and specific gravity has ceased to rise. The uniform gassing of all cells on charge is a good indication of their condition and the failure of any cell to gas is investigated before the charge is continued. During the charge, voltage and specific gravity readings are taken and recorded in the book and any cells not coming up to the proper voltage and gravity are closely watched and given special treatment if necessary.

Maintainers are required to make weekly inspection of all cells in service, examining them for loose connections, taking voltage readings and replacing any evaporation of electrolyte that may occur during the time the cells are in service. In replacing the evaporation, only water whose purity has been previously passed on is used. In localities where pure water is not obtainable, distilled water is provided.

*Abstract of a paper read at the meeting of the Railway Signal Association at Chicago, March 20.

†Signal Engineer, Oregon & Washington Ry. & Navigation Co., Portland, Ore.

A 30-TON ELECTRIC LOCOMOTIVE for heavy freight service has been ordered by Mr. H. A. Strauss, Consulting Engineer for the Salt Lake & Ogden Ry., and is the first of a number of such engines for this line. It will have four 100-HP., 700-volt, direct-current interpole motors, with forced ventilation. The equipment will include double-end multiple-unit control and combined straight and automatic air brakes. The engine will be built by the McGuire-Cummings Mfg. Co., of Chicago. It is designed to handle a train load of 400 tons (behind the engine) at 17½ m. p. h. on an average grade of 0.7%.

Supplying Water to Locomotives From Track Tanks.*

Track tanks are used to enable trains to take water while in motion. Their use up to the present time has been confined almost entirely to fast passenger trains making long runs between regular stops. But with increased efficiency from design of pans, methods of feeding, keeping water from freezing, and improved scoops, the track tank is being adopted for freight trains; especially where it is desirable to keep trains moving, in consideration of the excess cost of stopping and starting, the wear and tear of rolling equipment and the danger of breaking draft gear. The relative economy of the

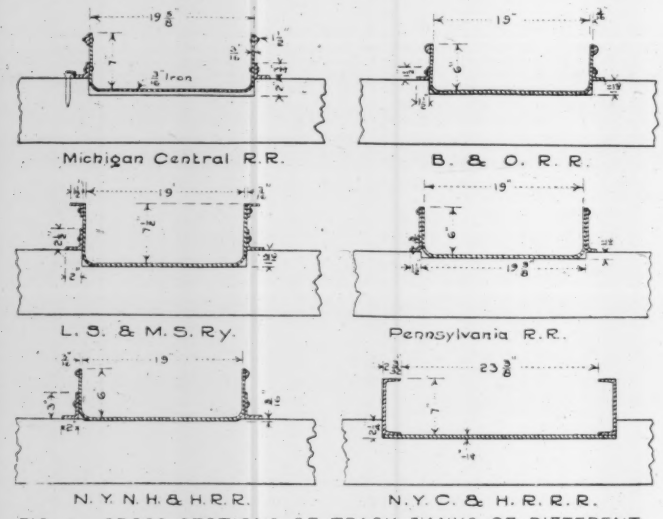


FIG. 1. CROSS SECTIONS OF TRACK TANKS OF DIFFERENT RAILWAYS.

delivery of water to locomotives by the track tank and by the tank spout or standpipe is dependent from an operating standpoint upon the following: First cost, interest, depreciation, maintenance, operation (including cost of water), loss of energy expended in drawbar pull overcoming the dynamic pressure of water from tank or scoop, speed of trains, ruling grade, loss of time and cost of stopping and starting (including wear and tear on rolling equipment), etc. These factors will have a wide variance for different locations and designs; hence each particular case should be figured separately.

The first track tank of which any record is given was installed on the London & Northwestern Railway, of England, about 1857, its inventor being Mr. J. Ramsbottom. The first track tank in this country was installed by the New York Central Ry. in 1870, at Montrose, between New York and Albany. It was for the use of the fast Saratoga trains, and was supplied with water by a hand pump. No provision was made against cold weather, its use being discontinued in the winter.

The first track tank in which provision was made for filling by steam pump and the heating of water during the winter, was installed by the Baltimore & Ohio Ry. in 1889 at Stanton, for the use of the fast passenger trains between Baltimore and Philadelphia. This has been used continually up to the present time. The filling is regulated by man operation and the water is heated during freezing temperature by steam admitted through nozzles in sides of tank.

The development of the design of track tank since the first installation by the Baltimore & Ohio Ry. has been inappreciable, but at the present time this method of delivery of water to locomotives is receiving the attention of the operating and engineering departments of several railways and the further development of the track tank and also the locomotive scoop is to be expected.

The track tank should be located on tangent, although it is possible to place it on curves up to 3° and obtain fair results. The Pennsylvania Ry. and the Philadelphia & Reading Ry. have tanks on 2° curves which have proved satisfactory. The disadvantages on curves, besides some additional first cost and cost of maintenance, are the difficulty of keeping the tanks in surface, and some additional waste of water from spray and water washing over sides.

The tank should be laid on level track, with grade of approaches such as to allow minimum speed required to properly take water. For this reason track tanks should be away from stations, yards, railway crossings, drawbridges, etc.

The tanks are set directly on ties dapped out to form a seat and allow top of tank to be at the same elevation as top of rail. The tank is held in position and anchored by side lugs fastened to ties by ordinary or special form of spike or bolt, with proper allowance for expansion and contraction. The section of tie should be larger than ordinary and of white oak or other hard wood. On account of the large amount of waste water thrown over sides of pan, special attention should be given to drainage.

The length of the tank is one of the factors which determines the capacity. The economical length is dependent on the width of tank, size and adjustment of scoop, quantity of water to be taken into locomotive tanks during a given time, and speed and time taken to fill pan.

Table I shows the dimensions of tanks used by different railways. Table II shows the water taken into locomotive tank with the corresponding number of gallons removed from track tank and wasted per foot of length of tank by scoop of cross-section 6½ × 12 ins.

The tanks in use are almost exclusively of built-up steel sections, although cast-iron and wood have been used with less success. The type of section is a matter of structural detail. The important considerations are rigidity, life and first cost. The depth should be 7 to 7½ ins., so as to allow top of pan to be at same elevation as top of rail with a maximum dap in tie of not more than 2 to 2½ ins. A width of 19 ins. has been found to be the most efficient and economical for the operation of fast trains and combined fast and slow trains. The larger width of 29 ins. has some advantage in the quantity of water taken into locomotive tank per foot of length of tank for slow speeds, but this is partly offset by the additional waste. Fig. 1 shows different sections of tanks that have been found to meet the requirements.

The end inclines should be substantially built to resist the impact to which they are at times subjected by badly adjusted scoops, hanging under gear, etc. They should be built as a part of the body of tank. The rate of incline should not be more than ¾ in. to 1 ft. of length.

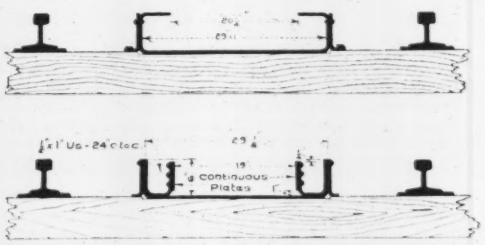


Fig. 2. Cross Sections of Special Track Tanks; Pennsylvania Ry.

The size and number of supply pipes should be determined from the pressure, number of openings and minimum time required to fill the tank. For expansion and contraction, proper provision should be made in the form of corrugated or rubber hose, or by packed or special joints. The placing of pipes in cross tunnels at inlets allows the taking care of water from broken pipes, assists in drainage and facilitates repairs. There are two methods of regulating the filling: (1) by man operation; (2) by automatic valve. The latter method is generally the more dependable and under average conditions should give the more economical and satisfactory result. The inlet should be so designed as to allow the minimum disturbance by flow of water into tank with corresponding minimum loss from friction. The deflector, enlargement of section of pipe at inlet and perforated plates are used at the present time.

To keep the temperature of water below the freezing point or to raise the freezing point to avoid or remove the formation of ice, so that water can be taken during freezing temperature, the following methods are used: (1) Blowing steam in water through nozzles in sides of pans spaced 20 ft. to 30 ft. apart; (2) circulating the water in the tank by means of a pump and heater or an injector.

WATER SCOOP.—The action of the scoop while taking water from the tank is more or less a blunt plow. At speeds above 30 m. p. h. it is very apparent that the velocity of the water entering into the scoop is less than the velocity of the tender; this has the effect of throwing out of the pan (especially at higher speeds) the water on either side of the point of the scoop and between it and the sides of the pan. As the speed diminishes below 30 m. p. h. a wave action is set up in front of the dipper, the water being piled up until it falls over the sides. This wave increases in size up to the point where the velocity imparted to it is less than that necessary to overcome the resistance due to gravity and friction, when, of course, no more water is lifted.

The dynamic pressure exerted by a surface moving in still water is equal to that produced by a stream flowing with the same velocity against a surface at rest. By the action of the scoop in the tank a dynamic pressure is produced in the opposite direction to the motion of scoop, the resultant, of which, is counteracted by the drawbar pull. (See Fig. 2.)

Let F = Force of impulse in pounds.
Let F^1 = Component of F in direction of initial motion.
Let P = Dynamic pressure in pounds produced in direction of initial motion = drawbar pull.
Let W = Weight of water removed from pan per second.
Let V = Velocity of scoop in pan in feet per second.
Let G = Acceleration due to gravity = 32.2.

$$F = W \frac{V}{G} \quad \ldots\ldots (1)$$

The water from tank entering the inside surface of scoop and the impact produced by water coming in contact with the outside surfaces of scoop develops the dynamic pressure and drawbar pull. The dynamic pressure produced by the water entering the inside surface of scoop depends upon its change of direction from Fig. 2:

$$P = F - F^1 = F\ (1 - \cos\ \theta) \quad \ldots\ldots (2)$$

Substituting for F its value as given in.....(1)

$$P = (1 - \cos\ \theta)\ W \frac{V}{G} \quad \ldots\ldots (3)$$

Assuming $\theta = 70°$ which is a very fair approximation

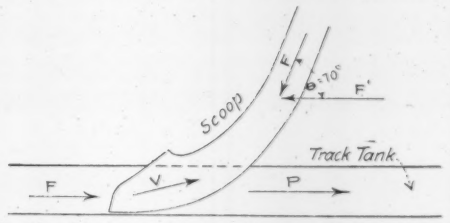


Fig. 3. Diagram of Water Scoop and Track Tank.

for the scoops used at the present time and substituting in (3) the values for $(1 - \cos\ \theta)$ and G.

$$P = .02043\ W\ V \quad \ldots\ldots (4)$$

The quantity of water which enters the inside surface of scoop is equal to the quantity of water taken into the tender, and the difference between this quantity and the total quantity removed from track tank is the waste which produces the impact by coming in contact with outside surfaces of scoop. The effect of this impact cannot be determined, but a fair assumption is that it will produce the same dynamic pressure as the same quantity of water entering scoop. Neglecting friction and other minor disturbance which are practically negligible the value of P as given in (4), in which W = weight of water removed from pan per second, is a fair approximation of the drawbar pull.

Drawbar pull = $P = .02043\ W\ V$.

Using the values W and V for 19-in. pans as derived from Table II the drawbar pull is found to be as in Table III:

TABLE I.—RAILWAY TRACK TANKS.

Railway.	Tank Length, ft.	Tank Width, ins.	Tank Depth, ins.	Heating.
Penna.	1,200, 1,500 & 1,800	19 & 29	6	2-pipe circulation.
L. S. & M. S.	2,000	19	7½	Steam, 2-pipe & 1-pipe circulation.
B. & O.	1,200	19	6	Steam.
Mich. Cen.	1,600	19⅝	7	Steam.
N. Y., N. H. & H.	1,250	19	6	Steam.
N. Y. Central	1,400	23⅜	7	Steam.

TABLE II.—WATER SUPPLY FROM TRACK TANKS.

Width of tank, ins.	Speed, m. p. h.	No. of gallons taken per foot of tank. Out of tank.	Into tender.	Per cent of waste.
19	20	2.10	1.70	19
19	30	2.20	1.90	14
19	40	2.20	2.00	9
19	50	2.35	1.85	21
19	60	2.80	1.70	39
29	20	2.90	2.20	24
29	30	2.90	2.30	21
29	40	2.65	1.90	28
29	50	2.70	1.70	37
29	60	3.00	1.50	50

Using the values of W and V for 19-in. pans as derived from Table II the drawbar pull is found to be as in Table III:

TABLE III.—DRAWBAR PULL AT TRACK TANKS.

Speed, m. p. h.	Drawbar pull, lbs.	Developed HP.
20	308	16.00
30	727	58.00
40	1,292	137.00
50	2,156	287.00
60	3,698	592.00

These values of the drawbar pull are in close approximation with values as found in actual tests. It will be noted that the drawbar and corresponding developed horse-power, for high speeds, would consume a large part of the available horse-power of the locomotive; but as the increase in the kinetic energy

*Abstract of the report of the Committee on Water Service, presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, at Chicago, March 21, 23.

of the moving train is in much greater proportion, for the higher speeds, the retardation effect of the scoop in water will not be very apparent, although it will effect some slowing up of the train.

The conclusions from a mathematical investigation made by Prof. I. P. Church (Cornell University) as to the scoop are that 22 m. p. h. is the minimum speed for taking water, and at 25 m. p. h. water is scooped into the tender satisfactorily; although more water is scooped into the tender at higher speeds, 40 to 50 m. p. h. working about the best. These conclusions have been proved by practical tests. It should further be observed that the adjustment of the scoop is very important.

The future development of the design of track tank will depend to a large extent upon the development of the design of the scoop, which affords more principles of design than the tank, and it is possible that the size and general arrangement will be entirely changed to obtain greater efficiency. With a set design of scoop the design of tank can be developed to give the maximum efficiency of the combined scoop and tank. The development of the design of scoop is being given consideration by several railways.

The Pennsylvania Ry. made several tests of track tanks and scoops at Atglen, Pa., in 1906. The tanks are on a 2° curve with the outer rail elevated and tank more or less out of surface, due to difficulty in keeping this portion of road, which is a fill, in proper condition. The Pennsylvania Ry. is making very exhaustive tests of water scoops and track tanks, using several special forms of dippers and shields.

The tests at Atglen included 19-in. and 29-in. tanks (similar to the Pennsylvania Ry. 19-in. tank in Fig. 1) and also a 29-in. tank with lips, as shown in the upper section of Fig. 3. The best results are obtained with the 19-in. tank, as indicated by Table IV. The committee report abstract above gives the particulars of the investigations by Prof. Church, and also discusses various piping arrangements for water heating and circulating. These details we omit, but we mention them for the information of any who may wish to investigate the matters more closely.—Editor.

TABLE IV.—COMPARATIVE RESULTS OF TESTS WITH TRACK TANKS; PENNSYLVANIA RY.

Speed, m. p. h.	Percentage of waste from tank*: 19-in. Tank, Per cent.	29-in. Tank, Per cent.	29-in. Tank with inside lips, Per cent.
20	35	19½	37¾
30	27	21	10
40	16	30	20 & 12¼
50	22	36	57
60	25½	44	..

*Representing difference between the amount of water taken from track tank and the amount received by the tender.

Track Tanks on the Lake Shore & Michigan Southern Ry.*

We have gone back to the narrow tanks, or those of 19-in. width, and have changed our methods of heating the track tanks during cold weather, installing at the present time what we call the one-pipe circulation method.

(1) The track under the tanks should be as nearly as possible of the regular construction, so that the section men can maintain and handle the ballasting. Hence it is desirable to eliminate all rigid steam or water connections.

(2) It is desired to have the water connections so made that as soon as a train has scooped, the tanks will be filled with water again in the shortest possible time, so that a train following will be able to obtain a supply of water. This we accomplish by installing water connections with automatic control of the valves, so that if water level falls the valves immediately open.

(3) It is as important to have freight trains scoop as it is for passenger trains, and with double-headers each engine should be able to obtain a full tank of water. We have found that track tanks 2,000 ft. long are ample to meet the above conditions, and that is our standard length.

(4) It is desired to have the simplest arrangement possible for keeping the water from freezing in the winter, and yet have a system that will keep all pipes and other breakable parts as far away from the track as possible. This we accomplish in our latest scheme of heating the water by what we call the single-pipe circulation system (Fig. 4). The 2,000-ft. tank is connected at seven tunnels (equally spaced) to a 4-in. circulation pipe, thus forming loops; outside of the circulation pipes a steam line is laid and ejectors installed. These ejectors cause the water to circulate, and by this means sufficient heat is added to the water to prevent it from freezing in the coldest weather.

The water supply is controlled by automatic valves, and as soon as the water in the track tanks is lowered by a train scooping, the valves immediately open and fresh water is supplied, flowing in the same direction as the ejectors force the water in circulating and heating. There are no rigid connections and track can be raised or ballasted without interfering with any pipe connections.

In the past we have had a large amount of trouble in maintaining track along the tanks, due to the fact that the waste water washed the ballast out from under the ties and caused the track to ride badly. This we have prevented entirely by laying 8-in. tile drains between tracks throughout the length of the tank, connecting these drains at each tunnel and disposing of the water through sewers connected to these tunnels.

In addition to the track drains, we protect the ballast from washing out by paving between and outside of the tracks with large flat flagstones, which answer two purposes: (1) The stones are very heavy and the water does not have sufficient force to dislodge them; (2) with these large stones the water has a quick run-off and the largest amount of it gets away quickly, so that it does not have a chance to soak into the embankment.

Our ballast cross-section across the track pans is somewhat heavier than at other points of the road and we try as much as possible to meet these conditions: (1) Cover the top of the original grade with granulated slag or pave with flagstones to prevent the clay from working up; (2) we put on these prepared surfaces about 18 ins. of crushed stone ballast below the bottom of the ties, and on top of this we again pave with large flagstones, as outlined above.

*Abstract of a paper by Mr. H. H. Ross, Assistant Engineer, L. S. & M. S. Ry., Cleveland, Ohio. This is an appendix to the committee report which precedes it.

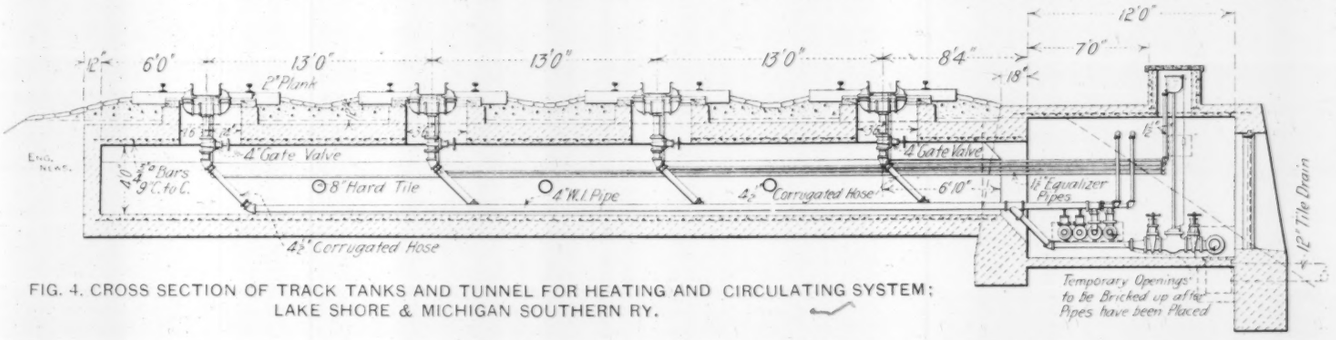


FIG. 4. CROSS SECTION OF TRACK TANKS AND TUNNEL FOR HEATING AND CIRCULATING SYSTEM; LAKE SHORE & MICHIGAN SOUTHERN RY.

Committee Reports: American Railway Engineering and Maintenance of Way Association.

The 22 regular and special committees of this association were all represented at the annual meeting by reports of some kind. Some were of a very extensive character, others of moderate length, and a few were brief reports of progress but accompanied by appendices of related matter submitted as information. All the reports were printed and distributed in advance of the meeting. A general, but brief review of all the reports was given last week in connection with our report of the meeting. We give below extracts from a few of the reports, dealing with individual subjects of interest, and more extended abstracts of some other reports will be given separately.

The Electrical Resistance of Timber.[1]

Timber is ordinarily classed with the non-conductors. When dry and well seasoned, it has a very high dielectric strength and practically infinite resistance. When green or moist, however, timber becomes a kind of electrolytic conductor of comparatively low resistance. The treatment with zinc preservatives has the simple effect of producing in the wood a stronger electrolyte and hence a better conductor of current.

(1) The resistance of timber varies directly with the length and inversely with the cross section.

(2) The resistance varies almost inversely with the amount of moisture present, between the limits of 15 and 50%.

(3) The resistance is lowest when measured along the grain, and highest when measured tangentially to the growth rings.

(4) When treated with a soluble salt such as zinc-chloride, the resistance varies approximately inversely as the amount of the salt present.

(5) Treatment with such a soluble salt does not change the behavior of the resistance with respect to the percentage of moisture present. Only the amount of the resistance is changed.

(6) The resistance of timber varies almost inversely with the temperature between the limits of zero and 50° C.

(7) The resistance of non-porous woods, such as the pines, is higher than that of porous woods, such as the oaks and red gum.

(8) Treatment of timber by different creosote processes does not greatly change the natural resistance of the timber.

(9) The conductivity of wood is due primarily to the presence in the pores of an electrolyte formed by an aqueous solution of the salts found in the natural timber, or of these salts and others artificially introduced.

Assuming the worst condition for leakage covered by the test, i. e., red-oak ties treated with zinc chloride laid in wet ballast and with wet rail bearings, the resistance between the rails of a block one mile in length would approximate 30 ohms. This would permit a leakage current of 0.05 ampere to flow with the battery voltage of 1.5 volts. The leakage loss would, therefore, be 0.075 watt, or about 30% of the power required to operate the relay. This should not seriously interfere with the operation of signals, as leakages up to 60% exist without such serious interference.

It is to be regretted that determinations of resistance were not made with wet ties or with ties and rails partially immersed in water, as is sometimes the case in practice, for it is believed that under such conditions the leakage current would probably be sufficiently large to interfere with the successful operation of relays.

The above results show only a reduction in resistance of a tie of from 26 to 53% when treated with zinc chloride (depending upon the percentage of moisture), while a change of resistance by the ratio of 25 to 1 may be effected by varying the kind of wood, a change of 33 to 1 by varying the pressure upon the tie sufficiently, and of 3.7 to 1 by temperature changes. It follows that the treatment of ties with preservatives should not interfere with the operation of signal circuits, except possibly in exceptional cases in which the resistance of the leakage paths is abnormally low from other causes.

[1]Abstract of an appendix to the report of the Committee on Wood Preservation; from a thesis by Mr. J. T. Butterfield, of the School of Electrical Engineering, Purdue University, Lafayette, Ind.

Track Fastenings With Treated Ties.[2]

The replies to a circular letter gave us information that would warrant a decision as to the best fastening. The committee makes this statement with full knowledge of the excellent paper of Mr. J. W. Kendrick, read at the last meeting of the Association. This paper, without doubt, points to the screw spike used in conjunction with tie-plates, and spike dowels as the best fastening yet devised. But the experience with other fastenings than the common track spike, and even the experience with treated ties, has been too recent in this country to furnish data for final conclusions. The following statements seem to be warranted by a study of the replies to the circular letters:

(1) Tie-plates with some form of fastening which can be removed and replaced at will without injury to the wood fibers are desirable. Such a fastening has not yet been fully demonstrated.

(2) In shoulder tie-plates the holes for outside fastenings should be so placed that the base of the rail does not bear against the body of the fastenings.

[2]From the report of the Committee on Track.

(3) Tie-plates should be flat bottomed, as projections of any kind tend to destroy the tie. This effect would be lessened, perhaps, if the tie-plate were independently fastened to the tie by screws other than the rail fastenings, and by use of the principle mentioned in paragraph (5).

(4) The bearing surface of tie-plates should be proportioned by each road to the resistance of the wood most largely used for ties on its line. In general, plates 6 ins. wide for hard woods and 7 ins. for soft woods should be sufficient, but some roads report trouble with plates of these widths.

(5) A tie-plate thicker through the whole or a part of the middle of its length than at the edges, with only a central bearing, is suggested for trial as theoretically sound. There would be less tendency for such a plate to rock under the action of the passing load and less pressure tending to force first one edge and then the other into the tie, and the plate would be strongest where the bending moment is greatest. The essentials of such a plate are the thicker central portion and the central bearing of the rail.

The Depth of Ballast for Railway Track.[3]

The proper depth of ballast under the ties will depend upon the conditions mentioned below. A report on "Strength of Track for High Train Speeds," made to the International Railway Congress by Mr. M. L. Byers (Chief Engineer Maintenance of Way, Missouri Pacific Ry.), which may be found in Engineering News, Feb. 3, 1910, is of considerable interest in this discussion.

(1) Character of Subgrade.—If the subgrade is of rock it will not be formed by wet weather and it will carry all the load that can be put upon it by a timber tie; therefore, the depth of ballast required is only that sufficient to provide an equal bearing under the tie and sufficient material for tamping purposes. If the subgrade is soft, then it is necessary to provide a depth of ballast which will produce as nearly as possible a uniform pressure on the subgrade. The softer the material, the deeper should be the ballast (within certain limits), to provide as uniform pressure on the subgrade as possible.

In a lecture by Mr. Schubert, at Berlin, in 1899 (Proceedings, American Railway Engineering and Maintenance of Way Association, Vol 7, p. 105), it was stated that with a roadbed consisting of clay, a swelling of same between the ties will not occur when the depth of ballast under the tie is increased 8 ins. over the clear distance between the ties.

(2) Kind of Ballast.—This does not materially affect the depth, although it is general practice to provide a less depth of stone ballast than gravel ballast. This is probably affected largely by the high cost of stone.

(3) Number and Size of Ties.—The number of ties per rail length, where the roadbed is soft, materially affects the depth of ballast; the fewer the ties, the greater the weight on each tie, and a greater depth will be required to distribute the load more uniformly over the subgrade.

(4) Stiffness of the Rail.—This materially affects the depth of ballast, for with the stiffer rail the wheel load is distributed over a greater number of ties. The unit weight being less, it is not necessary to distribute it as uniformly on the subgrade.

(5) Wheel Loads.—The greater the weight and number of wheel loads the greater the necessity for increased depth of ballast, so as to distribute the weight on the subgrade as uniformly as possible.

(6) Cost of Material—From an economic standpoint the proper depth of ballast frequently depends on the cost of the various materials of which the track is constructed. For example, where ballast is very expensive it may be advisable to increase the weight of rail and cut down the depth of ballast.

Cause of Failure of Monolithic Concrete Construction.[4]

In order to judge of the merits of monolithic construction we should examine the various causes which bring about the failure of masonry construction to ascertain whether or not monolithic construction will either prevent or delay failure when masonry is subjected to conditions that are likely to occur during their lifetime. Below are given causes for various masonry failures as taken from reports of various railways, and a report by Prof. Swain, which was gathered from various periodicals for the use of the Committee:

(1) Faulty Design.

(a) Where masonry is placed on grillage above the water line, the grillage rotting and allowing masonry to settle.

(b) Where grillage rests on piling and where the designer used too high a unit stress for timbers in compression.

(c) Where U-abutments have their wings built too light.

(d) Where the designer has allowed too high a unit pressure on the earth in front of the abutment or on piling upon which it may rest.

(e) Settlement which frequently causes a crack to appear where the wing leaves the main portion of the abutment.

(f) In arches, the wings sometimes separate from the body of the arch or the arch will frequently crack from 10 to 20 ft. on each side of the center line of the track, depending upon the height of the fill.

(g) Lack of proper drainage.

If the settlement in cases (a), (b), and (d) was not uniform in a large monolithic structure they would probably crack unless they were reinforced so as to prevent settlement cracks. If the structure was an ordinary single-track abutment up to about 20 or 25 ft. in height it would probably settle without cracking. If the abutments were built in sections the different sections would be divided in a vertical plane and prevent unsightly cracks.

In the case of arches under high fills and on ordinary soils it is difficult to prevent cracking of the arch abutment and ring unless reinforcement is used, on account of the pressure on the foundation in the center of the arch being very great when compared with the pressure at the end of the wing walls. The monolithic character of the arch abutment and the arch ring are not strong enough to distribute the load uniformly over the foundation, and when a slight settlement occurs in the center it causes cracks that are unsightly but seldom dangerous.

(2) Poor Material or Poor Workmanship.

(3) Temperature Cracks.—Several railways report temperature cracks in abutments, while other roads report abutments built of plain concrete in lengths of from 60 to 100 ft. without cracking, and when the abutment was reinforced in lengths of 150 ft. without cracking. There is evidently a wide difference of opinion as to the effect of changes of temperature on large monolithic structures. The front of the abutment has no forces to prevent its free contraction and expansion on the back, side and bottom of the abutment. However, the concrete contracts and expands more than the material adjoining it, and when the movement occurs the structure must be strong enough to overcome the friction between it and the adjoining material, or it will crack.

(4) Disintegration of the Masonry.

(a) On account of the freezing and thawing of exposed surfaces of masonry, particularly where water drips through an arch ring or where the masonry near the ground is exposed to alternate freezing and thawing. (b) On account of masonry being exposed to salt water, alkalies, acids or heat.

(5) Improper Filling.

(6) Material Sliding and Carrying the Masonry with it.—As to causes (5) and (6), a monolithic structure well designed will resist failure from both of the causes better than an abutment built in sections.

(7) Scouring Away of the Material Underneath the Masonry.

(a) On account of unusual freshets. (b) On account of driftwood, wagon bridges, etc., lodging against the masonry. (c) On account of ice gorges. (d) On account of the size of the opening being too small, which causes the water to rise during a freshet and which increases the velocity of the stream sufficient to scour away the material underneath the masonry.

In designing waterway openings the size is selected to take care of the maximum amount of water that is likely to come to it. It frequently happens that the amount of water has been underestimated or that the opening has been blocked by driftwood, ice gorges or other material which has induced scour in the bed of the stream or raised the high-water mark, or both. When the scour line is below the foundations of the abutments they are apt to move and tip forward or settle bodily downward. When this happens, a monolithic abutment will resist the pressure back of it better than one built in sections, because when one portion of the abutment is undermined the balance of the abutment will assist in preventing failure, and, even if the abutment does tip forward, the movement at times is slow, and failure can be prevented by relieving the pressure at the back or putting in props across the bridge opening.

In building abutments for subways it is frequently impracticable to build them as a single monolith; even if it were practicable, the abutment when underneath a number of tracks would be long, not very high and any slight settlement would cause an unsightly crack. The abutment would be in a prominent place, where any crack would be observed by the general public and create unfavorable comment.

Again, when abutments are built in horizontal layers and the work is not done continuously, wherever the work has been stopped long enough to allow the lower portion to set before placing the upper portion a seam has been found in the concrete, and when the backfilling has been made and becomes saturated with water the water will pass through the concrete through this seam. In city work this seepage is unsightly, it will form ice on the sidewalks in the winter time and the action of the frost will disintegrate the concrete. For these reasons it is desirable that when abutments are built in sections they be built of such length that each section can be built continuously.

Conclusions.—These conclusions are based upon the supposition that the structure is well designed and that the foundation is good:

(1) Monolithic concrete construction may be used without danger of cracking for abutments of any length that the working conditions will permit, provided the length does not exceed about three times the height.

(2) Where abutments with wing walls are not of monolithic construction, joints should be provided at the intersections of the wing walls and the body of the abutments.

(3) Reinforced-concrete abutments may be built in units of any length that economic conditions will permit.

(4) Monolithic concrete construction may be used for arches where the conditions will permit, otherwise the arch ring should be constructed with radial joints.

Concrete Fence Posts.[5]

The tests, observations and use of concrete fence posts during the current year indicate:

(1) Concrete fence posts are practicable, durable and economical.

(2) The 8-ft. post is recommended.

(3) Posts of cross-section approaching a square form are easiest made and most suitable for fencing.

(4) The spacing to be the same as for wood posts.

(5) Stone or gravel used in the concrete should pass a ½-in. square mesh. Concrete should be mixed wet, in a batch mixer, and poured into the molds. The poured posts are a little over 25% stronger than tamped posts of the same size, mixture and reinforcement; they are also better able to withstand the action of frost and alkali. Experience shows that extra precaution should be used in the selection of material, mixing of concrete, and handling and curing the posts. For the best results, posts should be allowed to remain in the yard undisturbed for at least 60 days after coming from the molds.

(6) Breakage in handling and transportation should not exceed 0.3%.

Roofing Materials for Railway Buildings.[6]

The annoyance and indirect expense occasioned by leaky and short-lived roofs are rarely compensated for by any possible saving in first cost. In selecting a roofing there should be considered:

(1) Chance of leaks due to character of construction. (2) Probable life, including chance of damage by the elements and by wear from other causes. (3) Fire-resisting value. (4) Cost of Maintenance. (5) Cost of Materials. (6) Cost of laying.

The ordinary practice of depending merely upon guarantees in selecting roofings cannot be trusted to secure proper results.

Where proper materials and the requisite skill in application are available, built-up roofs of coal-tar felt, coal-tar pitch and gravel or slag are recommended for roofs with a pitch of 2 ins. (or less) per ft. Where the roof is to be subjected to wear and where the character of the construction warrants the expense, flat tiles or brick should be used as a protective coating to the roofing instead of gravel or slag.

As a general proposition railway buildings should be designed to allow this type to be used, because of economy in construction and of decreased fire hazard. A slope of ½-in. to 1 in. per ft. is better than anything steeper. Nothing but straight-run pitch should be used.

No contracts should be made for a built-up roof without a complete and positive specification including flashings; and the contract prices should not be less than those of the materials specified, plus a reasonable amount to cover the cost of laying and profit. Thorough inspection of workmanship and material is recommended.

For slopes 2 to 6 ins. per ft. fair results can be expected if the top coating of pitch be specially prepared. This can be done successfully only by skilled workmen who are also necessary for its application. Special care must also be taken in the selection and application of the stone or slag coating.

Asphaltic compounds have value for a built-up roof for the top coating of slopes of 2 to 6 ins. per ft. They may be desirable also at points where good coal-tar cannot be obtained, except at a cost appreciably greater. They should not be used except where they can be obtained from reputable dealers, with complete information as to their constituents, and where they can be applied by men skilled in their use.

Ready or prepared roofings are recommended for use on small, temporary and other buildings, where the cost, considering maintenance, of more expensive buildings, is not justified. They are of value for steep slopes where a built-up coal-tar roof cannot be used, and for locations where the skilled labor necessary for a built-up roof is not available. The steeper the slope the greater their relative value and the wider their economic field. The heavier varieties are, in general, the more desirable because of their chance for longer life and their greater fire-resisting value. In making selections the reliability of the manufacturer, service tests and the cost should be governing factors.

In the laying of built-up and prepared roofings thoroughness in the preparation of flashings and work around openings is of vital importance.

Slate and tile of suitable quality, properly protected and fastened, can be recommended on roofs with a pitch of 6 ins. per ft. or over, where expense is not the gov-

[3]From report of the Committee on Ballast.

[4]From the report of the Committee on Masonry.

[5]From the report of the Committee on Signs, Fences and Crossings.

[6]From the report of the Committee on Buildings.

erning feature, and where they aid in producing the desired architectural effect, except that where there is much chance of driving snow, 8 ins. per ft. should be the flattest slope allowed.

Wood shingles, except in isolated locations where there is small danger from sparks, should not be used.

Steel or impure iron materials should be avoided, no matter how protected.

Fire Tests on Roof Coverings.[1]

Supplemental to the work of the Committee on Roofs and Roofings of the National Fire Protection Association which established specifications for the construction of several types of roof coverings, the Underwriters' Laboratories have during the past year designed and conducted a series of tests with a view of establishing standard test specifications by which all roof coverings may be classified according to their relative fire-resisting properties. It has been borne in mind also that the primary object of all roof coverings is to protect buildings and contents from the weather, and therefore an endeavor has been made to avoid requirements that would conflict with this primary function.

In the investigations made it has been the aim to establish a standard that would be sufficiently broad to permit the classification of roof coverings independent of the character of the roof structure upon which they might be applied. With this in view the tests have been designed to show clearly not only the relative flammability of roof coverings, but also their relative fire retardent properties, including the ability to resist the spread of fire on the surface of the coverings, protection afforded the roof structures against exposure to high temperatures, blanketing effect upon fires within the building, and also the flying brand hazard of the coverings. The effect of air currents of various velocities upon the coverings while under test was observed.

In adopting the test methods three separate fire tests were decided upon each of which approximates as closely as possible actual fire conditions and at the same time is capable of being reproduced for all classes of roofing coverings.

From the results obtained under the present method for testing combustible roof coverings, radiation and hot or burning-brand tests of a modified form were decided upon, and in addition to these a flame-exposure test was adopted. The methods of conducting both the radiation and hot brand tests and character of the furnaces used were entirely changed from methods formerly employed, so as to assure uniform conditions and at the same time permit of the testing of the roof coverings at the angle of inclination advocated for any particular type of coverings.

The radiation test consists of exposing the sample of the roof covering, to be tested, to the heat radiated from a steel plate heated to a prescribed temperature, and having an exposed circular area 36 ins. diameter, the sample being placed parallel to and at a prescribed distance from the surface of the radiation plate. For this purpose a cylindrical furnace was designed having a conical top and provided with a steel radiation plate at the bottom 42 ins. diameter. The furnace is composed of a steel shell lined with fire brick on top and sides, which forms the combustion chamber, and is carried on trunnions suspended from an overhead track. The radiation plate is attached to the bottom of the furnace by means of a circular frame which fits around the plate and is bolted to the sides of the furnace. The frame covers the edges of the plate 4 ins. and provides a net exposure of 36 ins. diameter. The joints between the frame and plate are made tight with fire clay.

The plate is heated by 12 gas-blast burners inserted through the sides of the furnace and so set that the gases of combustion impinge on the conical top of the furnace and are given a whirling motion. The temperature of the plate is measured on the radiating surface at the center by means of a thermo-couple rigidly attached to the plate by a small pointed clip which presses the point of the couple against the plate. The furnace permits of easy control and the temperature of the plate is even throughout and can be maintained uniform for any length of time with but slight variation.

In conducting the test the furnace is inclined at the desired angle and the plate heated to the proper temperature. As soon as the temperature has become constant, the sample is placed before the plate at the prescribed distance from it and at the same angle as the plate, the position of the sample being such that the lower edge of the plate is 12 ins. from lower edge of the sample. During the test the surface of the sample is exposed to air currents of known velocities. The sample is thus exposed until failure.

The burning brand test consists of applying to the standard sample a burning brand composed of maple strips, 3 ft. long, set side by side about 1 in. apart, forming a grid 3 ft. sq. The pieces are held rigidly together with cleats on the upper side. The brand is ignited by placing it over a gas burner consisting of rows of small jets, which play on all parts. The brand is permitted to burn until the wooden strips are thoroughly ignited and covered with incandescent coals and is then placed upon the sample.

In conducting this test the sample is set at the angle of inclination adopted for the particular covering and subjected to the desired air currents. The burning brand is then placed upon the covering so that its lower edge is 12 ins. from the lower edge of the sample, and permitted to remain until entirely consumed.

The flame-exposure test consists of exposing the sample deck to the direct attack of a gas flame. For this purpose a cylindrical furnace, about 4 ft. long, is used. It consists of a combustion chamber about 6 ins. diameter, having a narrow slotted orifice on the top 36 ins. long and ½-in. wide, and is provided with a shield which overlaps the sample, and makes up to the guide directing the air currents. Gas is supplied to the furnace through a perforated pipe, extending the full length of the combustion chamber. This is done in order to distribute the flow of gas evenly throughout the chamber.

The furnace is set at the lower edge of the sample to be tested, the shield overlapping the lower edge of the sample about 10 ins. In operation the flame emerges from the combustion chamber through the slotted orifice in the top, and is carried to the sample by the air currents, sweeping over an area of approximately 6 sq. ft., and being in direct contact with the surface of the sample. During the test the sample is exposed to the air currents in the same manner as in radiation and hot brand tests.

In order to insure uniformity in the results a standard roof deck upon which to apply the roof coverings was adopted. The deck is 7 × 8 ft., constructed of ⅞ × 8-in. undressed white pine boards, kiln dried, the boards being free from large or loose knots, sap or dry rot. They are laid across the shorter dimensions of the deck, spaced ¼-in. apart, and nailed to four battens placed on the under side of the deck. The roof coverings are applied to the decks in accordance with the specifications advocated for their application in the field.

For supplying the air currents a propeller fan 8 ft. diameter was adopted. The fan is driven by a 40-HP. motor and the speed controlled by means of a water rheostat. The fan is set in the partition in the end of the test room, and takes its supply directly from outside of the building. The furnaces are placed in front of the fan, and the air discharged is directed by guides to the sample under the furnace.

The air currents are controlled by regulating the speed of the fan, and their velocities are measured by means of a Pitot tube.

In order to conduct the tests a special building, 36 × 25 ft., was erected in the yard at the laboratories. The building is constructed of studding, sheathed on the outside with sheet metal and on the inside with plaster boards, and is divided into three rooms. In the largest the fire tests are conducted and furnaces mounted. Adjoining at the end is a small room in which radiator coils to regulate the temperature of the air currents are placed. The fan is built into the partition separating these rooms. The third room extends the full length of the building and contains the motor and water rheostat for operating the fan, and provides for the storage of samples.

With the apparatus installed, a number of tests were first conducted in order to calibrate the furnaces and to ascertain the effect of air currents of various velocities upon their operation. A second series of tests was then undertaken upon several representative types of roof coverings.

[1]Abstract of an appendix to the report of the Committee on Buildings, being an abstract of a paper by Mr. Geo. W. Riddle, Assistant Engineer, Underwriters' Laboratories, Chicago.

A Traction-Engine Excavator.

A novel excavating machine of the drag-line or scraper-bucket type is shown in the accompanying cut. It consists of a traction engine with excavator equipment. Coupled to the engine is a steel-frame platform mounted on two wheels, 36 ins. diameter and 20 ins. face. This carries a steel A-frame and boom and a two-cylinder steam hoisting engine. The truck is coupled to the engine in such a way that the latter forms its anchorage or counterweight, and the A-frame is guyed to the engine, as shown. The scraper-bucket is slung from the boom and handled by a hoisting line and a drag-line in the usual way. It may be dumped by an automatic trip when it reaches the head of the boom, or by means of the drag-line at any desired height.

When at work, the platform is supported by blocking so as to give a rigid support; side braces (resting on the ground) may be fitted also against the A-frame, in order to give it lateral support when the boom is swinging. For transportation from place to place, the A-frame and boom may be removed and loaded on a truck provided for the purpose. A single wheel is then put under the front of the excavator truck and this truck is attached to the engine by a long coupling bar. The length of boom is ordinarily 40 ft. and the bucket is of ¾-yd. or 1-yd. capacity. The hoisting engine handles the two bucket lines and operates the gear for swinging the boom; steam is taken from the boiler and the exhaust delivered to the smokestack by means of piping with double-swivel joints of special design. Hand gear is provided for operating the topping lift by which the boom is raised and lowered.

A DRAG-LINE EXCAVATOR OPERATED BY A TRACTION ENGINE.
(The Avery Co., Peoria, Ill.; Builders.)

This machine is built by the Avery Co., of Peoria, Ill. It is a special adaptation of that company's undermounted type of traction engine, the cylinders of which are mounted on a frame beneath the boiler, as in a locomotive. The machines have been used on a variety of work, including the grading of streets, excavating drainage ditches, building levees, stripping coal beds, and digging gravel. On ditch work in Illinois, a machine with a 30-HP. traction engine and 1-yd bucket has made as much as 400 ft. per day, with an average of 150 feet per day for a month's working. This ditch was in blue clay; it was 6 ft. wide at the bottom, 6½ ft. deep and about 20 ft. wide on the top. On levee work, the machine has handled 1½ to 3 yds. per min. in excavating heavy gumbo soil.

THE INITIATIVE, THE REFERENDUM AND THE recall for all California municipalities has been made possible by a bill recently passed by the California Legislature and signed by Governor Johnson of that state. This particular statute is quite independent of the commission plan of city government.

An Automatic Resuscitating Machine for Mine Rescue Work.*

The U. S. Bureau of Mines has received a number of automatic resuscitating machines, known as "pulmotors," which have been added to the equipment of each of the Government mine rescue cars. The greatest use of the apparatus is for preventing death of persons overcome by mine gases, but it is equally applicable to victims of electric shock or to apparently drowned persons.

The device operates automatically to inflate the lungs with oxygen and then to deflate them. The various parts comprise (1) a cylinder in which oxygen is stored under a pressure up to 125 atmospheres, (2) a blowing and a suction valve actuated by two accordion bellows, (3) a face mask which encloses the mouth and nose, making an air-tight connection with the face, (4) two flexible tubes, attached to the mask and leading to the blowing and suction valves respectively.

THE "PULMOTOR" IN SERVICE.

(On the right the old manipulation for resuscitation is being demonstrated.)

When the mask is made air-tight on the face and the oxygen turned on, the apparatus works automatically. Oxygen is forced into the lungs until a pressure of 4 ins. of water is reached. This pressure is also on one of the accordion bellows, and owing to its elongation the valves are turned and the pressure in the lungs released. The suction valve immediately begins to operate and continues to exhaust the gas from the lungs until a vacuum of 4 ins. of water is reached. The oxygen used for working this valve creating the suction elongates the second accordion bellows and changes the position of the valves, forcing the oxygen again into the lungs, etc. A lever enables the inflow and outflow of oxygen to be regulated by hand independently of the automaic device. The use of this device necessitates placing the patient on his back, in which position the tongue is apt to fall to the back part of the throat allowing the soft palate to close the larynx. To overcome this condition a flexible rubber tube is attached to the upper part of the face mask, which will admit of grasping the tongue with a pair of forceps to withdraw it sufficiently to raise the soft palate.

Another type of mask fits over the nose and nostrils only, allowing the mouth to be free. With the use of this nose mask the tongue may be withdrawn and held between the teeth and lips with sufficient pressure to hold it in place and make the mouth air-tight. For success with either mask, it is necessary that an air-tight fit be made.

Attached to the lid of the "pulmotor" box is an inhalation device which may be substituted for the pulmotor as soon as the subject under treatment recovers the involuntary action of the lungs. This inhalation device is fitted with a rubber bag which holds two liters of oxygen when inflated and a metallic mask which fits over the mouth and nose and which may be held in place with a rubber band passing around the head. A lever at the hinged end of the box has enameled inscriptions, "pulmotor" and "inhalation." Whichever of the names as are exposed indicates the manner in which the apparatus will operate.

To demonstrate the action of the device there is provided a rubber bag and a disc which may be attached to the face mask. The rubber bag when so fitted represents the lungs of a subject being treated. These machines were made by the Draeger Oxygen Apparatus Co., of Germany, which has a branch in Pittsburg, Pa.

*From information supplied by the U. S. Bureau of Mines, Washington, D. C.

The Design of Passenger Terminals of Medium Size.*

In the design and construction of terminal facilities the object should be to provide such arrangement of tracks as will permit the greatest freedom of movement with the least interference, to the end that incoming and outgoing trains may be handled without serious interruption or delay. In this way will be secured the maximum efficiency of tracks and facilities and the minimum expenditure for installation.

In the operation of terminal stations many, and in some cases most, of the trains handled have to be hauled out of the station after they are unloaded, and placed in a car-cleaning yard. Unless the facilities are ample, they must be moved again after cleaning, and placed on storage tracks. From the storage tracks they are shifted in proper order and placed on a track in the station for outward movement.

If it is necessary at any time to provide for trains arriving or departing (or both) in rapid succession it is very important that the track layout be so arranged that the inbound and the outbound movements will not conflict to any great extent. This will make it possible not only to permit trains in many cases to enter stations at the same time that other trains are departing, but also to fill vacant tracks in the least possible time after outgoing trains have left them. This, in turn, will secure maximum efficiency and will reduce to a minimum the number of tracks in a station to properly handle the business.

The train capacity of tracks depends largely on the facilities provided for rapid handling of the baggage and express matter that is loaded and unloaded while trains are standing at station platform. It follows, therefore, that in order to handle the largest number of heavy trains within a given time these facilities must be the best that conditions will permit, and, if possible, such arrangements should be made as will eliminate interference with the movement of passengers. To this end it is suggested that where it is possible to do so, baggage and express should be received, delivered and handled below or above the train floor and raised and lowered by elevators located near the baggage and express cars. This will avoid trucking long distances on platforms used by passengers, to the great discomfort of all concerned and the loss of much valuable time.

There is a very wide variation in the time to load and unload passengers, baggage and express at stations, depending largely on the character and volume of the business handled by different trains and the facilities provided to insure rapid movement. As a rule the passengers can be loaded on long-distance trains in much less time than is required to handle the baggage and express, but with the short distance and suburban trains (on account of the comparatively small amount of baggage and express to be handled) the condition may be reversed. In any case it is evident that to secure the greatest efficiency in handling a passenger terminal the time required to load passengers and ordinary baggage and do necessary shifting must be considered as the time interval between the departure of trains on any tracks. Therefore, the express, theatrical and other extra heavy baggage should be loaded prior to making up and placing such trains at the passenger platforms.

The operating officers in charge of the large number of stations covered by our investigations place widely divergent estimates of maximum capacity of station

*Abstract of the report of the Committee on Yards and Terminals, presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, at Chicago, March 21, 23.

FACILITIES AND TRAFFIC OF LARGE AMERICAN RAILWAY STATIONS.

Station.	Type.	Location of		No. of Trains Daily.				No. of Trains in Busiest Hour.		Est. Max. No. of Trains that could be handled in 1 hour		Tracks.		Platforms.			Distance to	
		Building to Tracks.	Tracks to Street.	Through	Originating.	Terminating	Total	Total	On One Track.	Total	On One Track.	No.	Spacing c. to c., ft.	No. and Width, ft.	Length, ft.	Ht. Above Top of Rail, ins.	Engine House.	Car Storage Yard.
1. Chicago: Dearborn (Union)	Term.	At end	St. level	0	53	55	108	14	3	17	3	10	....	.....	670	6	5 mls.	5.6 mls.
2. Hoboken: D. L. & W. Ry.	"	"	"	0	127	118	245	29	5	54	8	14	13	(8) 20, (1) 17	700	6	1,800 ft.	600 ft.
3. Jersey City: Erie Ry.	"	"	"	0	123	126	249	28	8	33	12	10	15	(5) 15	650, 700	2	800 "	700-4500
4. Long Island City: L. I. Ry.	"	"	"	0	135	134	269	60	5	65	12	24	24	(9) 14	760	9	¼ ml.	¼ ml.
5. New Orleans: Union.	"	"	"	0	11	11	22	6	2	12	3	4	24	(2) 17	704	7	....	....
6. Cincinnati: "	"	"	Under	0	69	67	136	28	4	30	5	8	....	(4) 13 & 15	650	10	....	....
7. Louisville, Ky.: "	"	"	St. level	6*	24	24	54	14	3	32	12	6	26 & 20	(3) 17, (2) 11	450, 600	6	1,800 ft.	2,800 ft.
8. Savannah, Ga.: "	"	"	Over	10*	8	8	26	....	....	....	....	9	14 to 25	(4) 15, (3) 10	600	7	2 & 4 mls.	9,300 "
9. Columbus, O.: "	Through	At side	Under	25	34	35	94	19	4	19	5	8	11	(1) 11, (3) 17	(2) 678, (2) 774	8	....	....
10. Philadelphia: B. & O. Ry.	"	"	"	20	14	14	48	6	3	12	4	6	12 & 13	(2) 23, (1) 12	760	0	1 ml.	....
11. Baltimore: (Mt. Royal) "	"	"	"	26	12	6	44	8	6	12	6	5	12	Shed area	426	0	2,500 ft.	2,500 ft.
12. Baltimore: B. & O. Ry.	Both	Both	At & under	37	20	25	82	6	2	12	3	7	12 & 50	(3) 15	610	15	3,000 "	2,500 "
13. Peoria, Ill.; Union.	Through	At side	St. level	0	43	39	82	14	4	78	12	7	....	(1) 18, (1) 6, (3) 12	480	0	1½ mls.	Adjac't
14. Troy, N. Y.: "	"	"	"	57	24	20	101	14	7	25	10	7	12	(4) 12	(3) 400, (1) 310	10	1 ml.	1 ml.
15. Albany, N. Y.: "	"	"	....	88	35	34	157	17	6	17	6	8	....	(3) 28, (1) 27	650, 850	6	¾ ml.	Adjac't
16. Reading, Pa.: P. & R. Ry.	"	"	Over	32	14	14	60	12	3	30	5	....	....	(1) 20, (2) 15	1,100	8	1 ml.	"
17. Harrisburg, Pa.; Pa. Ry.	"	"	Und. & over	55	47	45	147	8	5	30	6	8	12	(5) 37 & 22	765, 800	7	4,150 ft.	650 ft.
18. Birmingham, Ala.; Union.	"	"	St. level	6	20	20	46	....	....	....	....	10	12	(5) 19½	(3) 620, (2) 770	8	¼ to 1 ml.	¼ to 1 ml.
19. Milwaukee: C.M. & St.P. Ry.	"	"	"	22	30	32	84	12	3	20	6	5	18 & 20	Shed area	1,000 max.	0	2 mls.	¼ ml.
20. Minneapolis: Union.	"	"	Under	44	30	30	104	16	2	30	2	6	26	"	1,200	0	....	....
21. Indianapolis: "	"	"	St. level	46	42	40	128	30	4	37	5	8	....	"	....	0	⅛ to 1½ mls.	½ to 1¼ mls.†
22. Toledo, O.: "	Both	"	Under	43	39	40	122	....	....	....	....	13	12	(3) 26	....	0	Adjac't	Adjac't
23. Nashville, Tenn.; Union.	"	Over	"	10	26	26	62	11	2	15	4	10	20 & 28	(5) 20, (4) 11	550, 750	9½	800 ft.	800 ft.
24. Richmond, Va.; Union.	"	Both	Over	10	7	7	24	....	....	....	....	9	12 & 23	(2) 8, (5) 14½	650, 1,248	....	⅞ to 3¾ mls.	½ to 3¾ mls.
25. St. Paul, Minn.: "	"	"	St. level	92	46	46	184	42	5	42	5	14	13 & 26	(8) 16	800	12	⅛ ml.	⅛ ml.
26. Seattle, Wash.; "	"	"	Under	6	35	36	77	....	....	....	....	11	12	(4) 18	200	0	None	1,000 ft.

* Reverse movement for through trains. † Pullman yard adjacent to station.

tracks. These estimates range from 2 to 12 trains that could be handled on one track, with an average of about 6.5 trains per hour. These figures no doubt represent a very close approximation to the very best results that could be accomplished for a period of time not exceeding one hour and only after preparation had been made, and therefore do not indicate results that could be expected if a continuous performance were required. At the same stations we find that the actual performance is from 2 to 8 trains, with an average of 4.1 trains handled on one track during the busiest hour. It follows, therefore, that under average existing conditions the actual performance during busiest hours is approximately 4 trains per hour on busiest tracks and that a maximum average of 6.5 trains per hour could be accomplished on some tracks. It is to be noted, however, that the stations at which high estimates of efficiency are made either have through tracks or do a large suburban business with light trains.

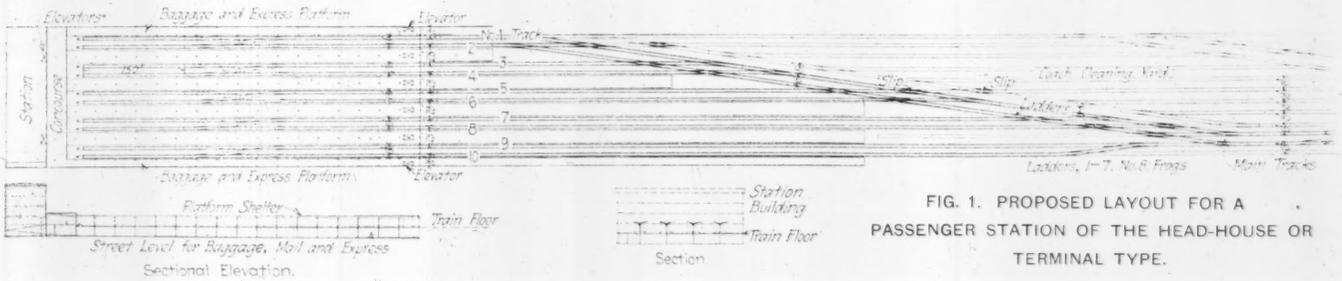


FIG. 1. PROPOSED LAYOUT FOR A PASSENGER STATION OF THE HEAD-HOUSE OR TERMINAL TYPE.

If, however, facilities can be provided that will permit continuous and rapid handling of baggage and express without interference with the movements of passengers, it is believed that results approximating the best estimates can be maintained for much longer periods of time, and that the average of 6.5 trains per hour is well within the limit of efficiency that can be secured. But to do this it is conceded that the station, the track layout and all facilities must be designed in harmony and with the principal object of saving time in handling, and thereby securing results that would ordinarily require a larger installation.

With this object in view, we have considered the subject of track layouts at terminal passenger stations, both dead-end and through, and present diagrams showing typical layouts embodying and illustrating the suggestions submitted. (Figs. 1 and 2.) The plans represent generally desirable and advantageous arrangements of tracks; they are not submitted as standard plans.

In our report of last year, we presented a compilation showing the general characteristics of 26 passenger terminals of medium size located in cities in this country. We have secured additional information as to results obtained in operation, and also estimates as to possible efficiency. This information is presented in the accompanying table. From this it appears that a number of stations at important points are now working close to the limit of their capacity and are showing very creditable efficiency as to operation. But as they are being worked beyond the limit for which they were designed, it is reasonable to suppose that the cost of operation is excessive and that, therefore, some rearrangements and improvements would be advantageous, to save time and reduce cost of handling.

In the plan of a dead-end station with eight platform tracks (Fig. 1), the double-track arrangement at the entrance is preserved to the greatest possible extent, so that the use of station or platform tracks may be made practically continuous. Results are thereby secured closely approximate to the best that could be secured in a station with through tracks and the same length of platforms. It is suggested that where large numbers of passengers arrive in quick succession (as in the case of suburban traffic), full consideration should be given to the question of providing the passages for egress with inclined floors instead of stairs, with the object of increasing capacity and preventing congestion. It is recommended that the grade or fall of such sloping floors be not greater than 1%, and that all such floors be kept rough at all times, so that slipping may be avoided.

At stations of either type the time required to place a train on a station track, load it, and clear the track for another train is the minimum time interval between departures of trains from any one track. Therefore, to secure maximum efficiency the track layout must permit operation practically without interference, as in stations with through tracks, and baggage and express handling must not retard the movement of trains beyond the time needed to properly handle the passengers.

In regard to the dead-end terminal plan, the only feature upon which stress is laid is the provision made at the ends of the station or platform from tracks to promote rapid handling of trains and to avoid interference between the inbound and outbound trains. This feature can be applied much more extensively than has been attempted as yet.

It is believed that the track arrangement shown is exceptionally well adapted for the handling of a large number of trains in and out of eight platform tracks at minimum cost and in a minimum time.

In regard to the track layout for a through station (Fig. 2) it will be noted that the location is shown at a junction of two double-track roads. A separate station platform is provided for the movement in each direction. All trains making the station stop must be switched from the main track to one side or the other of one of these platforms, thus clearing the main line while the stop is being made. In some station plans a middle platform separates the two pairs of tracks, but in the opinion of the committee it is unnecessary to switch trains across one of the through tracks (as with a three-platform plan). Therefore, the double station or double platform plan was adopted, the two main tracks being continuous and on their proper line through the station.

A station of this kind has almost unlimited capacity, and, therefore, there is comparatively little necessity for much additional trackage. The platforms being of ample size, four ordinary trains can stand at the platform at one time. As these platforms are approached from the bottom, and the baggage and express are handled by elevators, there would be very little interference and the station would be found to have very great capacity.

A Water Supply for Athens, Greece.

Athens was founded 3,471 years ago, and although it has to-day, with its port of Piraeus, a population of 256,000, with many modern buildings equipped with up-to-date sanitary conveniences, it has never had an adequate public water-supply. For all these years shallow wells in and about the city have been used for ordinary purposes, while all the water fit for drinking has been brought into the city in casks and barrels by carts.

According to London "Engineering" of Jan. 6, 1911, an English syndicate has been assured of the contract, for which both French and Austrian engineers also competed, of providing a water-supply for a possible population of 400,000 at the daily rate of 36 U. S. gals. per capita. The present general supply amounts to less than 12 U. S. gals. per capita per day at Athens, and even less than this at Piraeus.

Surveys have been made by this syndicate at a cost of $40,000, and the source of supply determined upon is in the Mountains of the Peloponnesus, 88 miles from Athens. Here at Lake Stymphalia is an abundant supply of pure water which issues from springs in the limestone sides of the mountains. The rainfall in these mountains is exceptional for Greece, the gagings showing a mean annual fall of 39.37 ins., whereas in the Valley of Attica, in which Athens and Piraeus are located, the fall is but 16 ins. The water is palatable and free from any contamination.

Steel lock-bar pipes will be used for the mains except at the extreme upper lengths where there is very little pressure. For this part of the line plain concrete pipe, with patented joints made of a steel band bedded in a special bituminous preparation, will be used. As the country is subject to earthquake shocks, a rigid joint of any kind could not be used. Cast-iron pipe was rejected because of the difficulty in transportation and their liability to breakage. Riveted steel pipe was likewise rejected on account of its liability to weep along the joints and the dangers consequent on bad riveting.

The two most interesting features of the pipe line are the crossing of the Corinth Canal and the passage through the Kaki Scala Pass. For crossing the canal two trusses of the Pratt type, 272-ft. span, will be used. The trusses are 12 ft. high and 10 ft. between centers, and the maximum chord section has 9½ × 12-in. plates. They are designed to carry an 18-in. and a 31-in. pipe. The height of the lower chord above the water of the canal is 162 ft. 6 ins. At Kaki Scala Pass the conduit will run along the side of a cliff on the shore of the Eglan Sea. A roadway supported by a wall with counterforts or buttresses is built along this cliff. The pipe will be placed under this roadway, and in narrow places steel I-beams will be placed longitudinally between the counterforts in the space between the pipe and the outside face of the wall. This will give the lateral support necessary to keep this weight of the pipe from pushing out the wall. Every alternate counterfort will be strengthened to carry the additional load.

The site of the once opulent city of Corinth is crossed near the foot of the Acropolis, from the steps of which St. Paul delivered his sermons to the Corinthians. The Greek Government has acquired in advance all rights to the treasures of antiquity which it is expected will be unearthed here.

To secure the best distribution of water for Athens, the city is divided into three zones, high, middle, and low-level, with storage reservoirs for each. After one-third of the supply has been diverted to Piraeus, the remaining two-thirds will be conducted into the middle reservoir. From here nearly one-half daily distribution will be made and the other half conveyed through 24-in. cast-iron mains to the low-level reservoir, using it on the way, however, by means of turbines connected to pumps, to raise about 840 U. S. gals. per minute to the high-level reservoir. This leaves about 3,265 U. S. gals. per minute for power and for supply within the lower zone. A 12-in. cast-iron branch for the high level supply will be taken directly to the pumps so that the water raised does not pass through the turbines.

About four years are expected to complete the work after the commencement. All ordinary materials and labor are easily obtainable on the ground, but all pipe, fittings, machinery, etc., must be brought from England. Timber cannot be secured in Greece but must be brought from Russia and Turkey. The estimated cost of the works and all contingent expenses is 7½ millions of dollars.

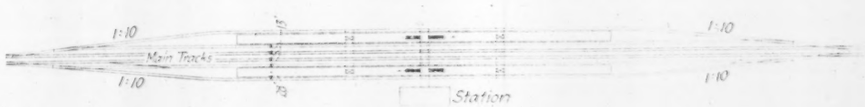


FIG. 2. PROPOSED LAYOUT FOR A PASSENGER STATION OF THE THROUGH TYPE.

Charles Wallace Hunt.

By F. R. HUTTON,* M. Am. Soc. M. E.

In the death of Mr. Charles Wallace Hunt on Monday, March 27, there has passed from the stage of contemporary engineering a figure which was notable in many ways. The personality of the man was so manifestly behind everything that he said and did, that it is difficult to apportion the respective share of professional and other ability and of personal character in the combined result.

Mr. Hunt was born at Candor, in Tioga County, in the western part of New York State on Oct. 13, 1841. He was educated at Cortland Academy, Homer, N. Y., taking the scientific course of that day with a view to becoming a civil engineer and going into railway work. His plans were changed, however, by the outbreak of the Civil War, and instead of entering into professional life at that time, he became a special agent of the War Department under Secretary Stanton, his services being rendered chiefly in looking after the colored freedmen as they escaped into the Union lines from the Confederacy.

For several years after the war, Mr. Hunt was out of health and in no active business. When he was able to re-enter the field of current affairs, he became a coal merchant with yards upon the shore of Staten Island. In his yards the coal was handled from the barges to the storage bins in the good old-fashioned way. A bucket was lowered into the hold of the barge and shoveled full of coal by hand labor amid the dirt and dust of the cargo. It was then hoisted by horse power by means of a whip tackle, swung around over a bin or cart by human muscle and then emptied. The expense of this crude method of handling material early forced itself upon Mr. Hunt's attention, and in 1872 he started the business of building machinery for the mechanical handling of coal, ore or similar material for industrial establishments, railroads, steamships and the like. Such machinery reduced the cost of yard hauling from 30 cts. per ton to 3 cts.

His talent for mechanical invention introduced into his business a number of novel devices. His first scheme was an automatic self-filling scoop or grab bucket, which, when filled from the boats was raised to the level of an overhead railway, and on that railway was run back from the bulkhead to the desired bin, where it was automatically tipped and emptied, and run back again to the receiving point.

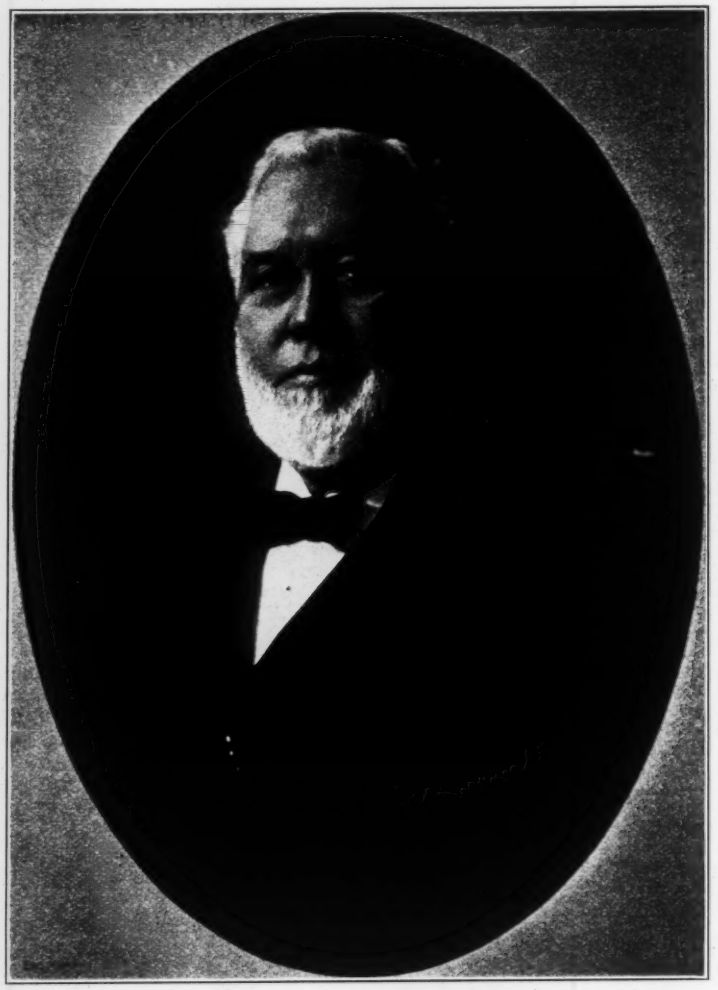
In planning this device, Mr. Hunt's early scientific training was drawn upon, and he took advantage of the peculiar properties of the parabola to eliminate a change in the length of the wire rope when the bucket was swung out from the boom of the crane. This system of handling was introduced on many railroads and dock fronts.

At a later date Mr. Hunt adopted the McCaslin system of continuous conveying as a substitute for the intermittent system on which his earlier business was based. Steel buckets carried upon a pair of sprocket chains could be led over guide pulleys, the bucket moving continuously and always level and being tripped to discharge its contents at any desired dumping point.

In a competition between this continuous conveyor and a rival device using stationary steel troughs over whose concave surface the coal was drawn, Mr. Hunt had the opportunity to offer a parallel which has greatly entertained his friends. Before a committee which had to decide on the relative merits of the two systems, Mr. Hunt said, "If you had a cat in one corner of a room, and desired to locate the cat in the diagonally opposite corner, would you catch him by the tail, and against his resistance, with claws embedded in the carpet, forcibly drag him to the further corner; or would you lift him into a basket, and easily and jauntily carry the cat through the air, and deposit him at the desired point?"

This was a clever piece of salesmanship, and the genial humor of it was characteristic of Mr. Hunt.

The needs of his extensive business stimulated Mr. Hunt's invention in a number of directions. He designed small steam engines for his conveying machinery in which no harm could come to the engine from excessive condensation of steam in exposed places. He gave careful study to the problems of rope driving. He designed a connecting rod in which the take-up for wear was effected by the displacement of steel balls. He early went into the development of the electric storage battery to operate the light electric locomotives which he designed for indoor transfer in factory buildings and yards. In fact, it is probably by his "Industrial Railways," as he called them, that Mr. Hunt is more widely known than by his coal handling plants. His design of tracks, turntables, switches and trucks for the service of coal in boiler rooms, and for the removal of ashes became a very large part of Mr. Hunt's later business. His coal handling machinery was manufactured in Germany and England, and travelers on the continent find it in extensive use. Mr. Hunt took out patents upon his various inventions amounting to over one hundred and fifty.



Charles Wallace Hunt

By reason of his personal character and the importance of his business on Staten Island, he became an influential citizen to whom numerous responsibilities were entrusted. He was Director, Vice-President, and President of the Richmond County Savings Bank, and President of the Staten Island Chamber of Commerce. He took active part in the Natural Science Association of Staten Island, while enjoying an active participation in the social and business men's clubs both of New York and of his home town. He was a member of the American Institute of Mining Engineers, the American Institute of Electrical Engineers, the Franklin Institute, the American Association for the Advancement of Science, the New York Electrical Society, the New York Railway Club and the National Geographic Society, and was for some time a member also of the American Society of Civil Engineers.

His close affiliation, however, with the art of machinery design and construction made him naturally a prominent figure in the American Society of Mechanical Engineers. He joined it in 1885 and was made a vice-president in 1892 for the two-year term. He served as a Chairman of the Society's important Committee on Publication, and later, upon the introduction of the policy of administration of the Society by Standing Committees, he was made the first Chairman of the Finance Committee under that reorganization.

In 1898 He was elected President of the Society and presided at the 37th meeting in Niagara Falls, and the 38th meeting in New York. Under a provision of the Constitution of the Society of Mechanical Engineers, the former Presidents have the privilege of attendance and service on the Council of the Society; and probably no past-president has ever been as assiduous and constant in his attendance at meetings of the Council as Mr. Hunt, even when the pressure of his personal business was most insistent.

When the Constitution of the Society needed revision about 1902, Mr. Hunt was made Chairman of the Committee which undertook that work and carried the laboring oar in the long months of digestion and preparation of the Constitution and By-laws which were enacted in 1904. So important was his work and so familiar had he made himself with the legislative workings of the Society that during the seven years since the Society adopted its existing Constitution, Mr. Hunt has been kept as Chairman of a continuing committee to consider and report upon changes which experience has seemed to make necessary. In the many directions in which Mr. Hunt will be missed, there is perhaps none in which his loss will be more greatly felt than in this inconspicuous line, of his devoted activity. He presented several practical papers for record in the Society Transactions.

When Mr. Andrew Carnegie in 1903 made his notable deed of gift to be devoted to a building for the Engineering Societies, Mr. Hunt was promptly chosen as a member of the organizing committee, and later of the building committee, and finally of the Board of Trustees. He was very largely responsible, with Mr. S. S. Wheeler, for the complete and admirable constitution of the Board of Trustees of that building. He continued in office during two terms, falling out only under the principle, which he himself recommended, that no trustee should be immediately re-eligible at the close of a second term. After a year had elapsed, however, he was put back to serve again, in the position in which he had done such great service. He was at the beginning of his third term when death overtook him.

*Consulting Engineer to Department of Water Supply, Park Row Building, New York City.

His influence in the Board was singularly conservative for one who occasionally broke forth into most radical suggestions. His recommendation that no decision of the Building Committee should ever be carried out until the entire Board was unanimous respecting it, was largely responsible for many well balanced decisions as to details of the building and the consequent satisfaction of all parties in it. Up to the very beginning of his last illness he was active and suggestive respecting certain propositions looking to the development of the library and of an enlargement of its scope.

Mr. Hunt was twice married, in 1868 and in 1889. Four children survive him. His last illness was full of discomfort and suffering due to symptoms of acute asthma under the fatigue of which even his strong body was finally forced to succumb. The funeral was held in the church at West New Brighton, in which his interest had been keen for many years, on Thursday, March 30, and deputations from the Engineering Societies, and the Engineers' Club attended as official delegates. He was laid to rest in the beautiful cemetery at New Dorp.

An Electrically Operated Grain Elevator and Wharf Conveyor System at East Boston, Mass.*

The destruction by fire of most of the water-front properties of the Boston & Albany R. R. at its terminal and docks at East Boston, Mass., some two and a half years ago, necessitated the development and construction of an entire new plant for the purpose of transferring and shipping the grain consignments received at this point. The Witherspoon-Englar Co., of Chicago, specialists in the design and construction of grain elevators, were commissioned to prepare the necessary plans for a new plant at East Boston, and later this firm was awarded the general contract for construction. This plant, consisting of a grain elevator, dryer house, dust house and wharf conveyor system has recently been completed and put into regular service.

GRAIN ELEVATOR.—The elevator, shown in Fig. 1, is a fireproof structure 73 ft. wide, 269 ft. long and 185 ft. high. Of the height 72 ft. is taken up by the storage bins, which have a capacity somewhat in excess of a million bushels. The general arrangement of the elevator and the machinery equipment, while representing the most modern practice and embodying the latest improvements, is very similar to that found in other elevators designed and built for this particular class of service. The operation however is novel and interesting. The elevator stands on the street side of the railroad property and 244 ft. from the dock line, the yard tracks and a team driveway, to the pier sheds, occupying the space between. There are three sheds, affording berth accommodations for six vessels at one time. Three of the piers are approximately 600 ft. long and the other three are approximately 800 ft. long.

CONVEYOR SYSTEM.—The wharf conveyor system consists of a number of overhead galleries with towers at the various connecting points, housing belt conveyors which carry the grain from the elevator and distribute it conveniently over the various pier sheds, where, by means of suitable loading spouts, it may be conducted to the hatches of the vessels loading at the wharves. Within, and for the full length of the elevator, there is a shipping conveyor gallery, which is connected by two inclined galleries bridging the yard tracks to the main trunk of the pier distributing system. The main trunk gallery is located over the driveway which skirts the water-front, and from this main trunk, two wharf galleries branch off at right angles over each of the pier sheds.

These last galleries extend practically the full length of the pier sheds and afford some 50 loading points, at each of which an adjustable ship-loading spout is provided. The aggregate length of all the galleries is something over 6,000 ft. The main trunk and each of the connecting galleries contain two 36-in. belt conveyors. Each of the wharf galleries contain one 36-in. belt conveyor. The motors and the machinery required for driving the belt conveyors are located in the various towers, which also contain the distributing valves and spouts for diverting the grain from one belt to another. It is possible to so arrange the operation of the belt conveyors and distributing spouts that grain may be delivered to four vessels at one time, furnishing 10,000 bushels per hour to each. The distance from the elevator to the motor in the farthest tower is approximately 1,200 ft., and there are five motors in intermediate towers. It is no exaggeration to say that the development of this remarkable and extensive conveyor system is rendered possible only by the use of the electric motor drive.

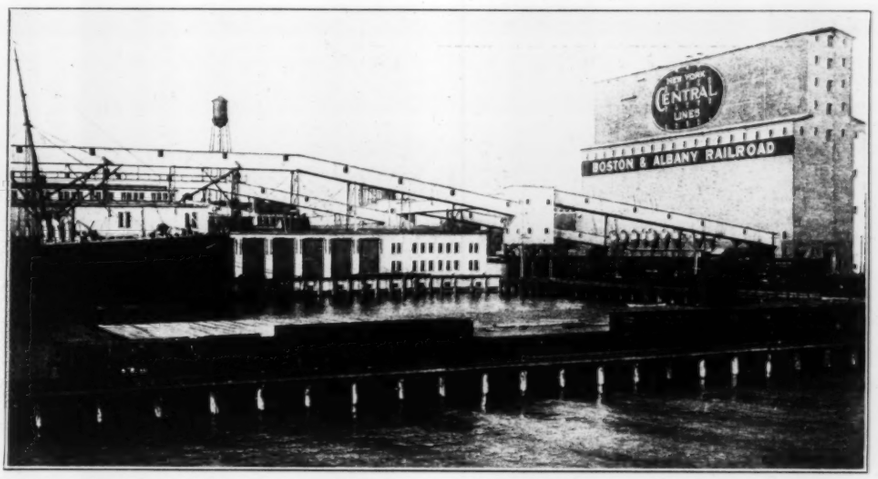


FIG. 1. ELEVATOR AND CONVEYOR PLANT OF THE BOSTON & ALBANY R. R. AT EAST BOSTON, MASS.

MOTOR DRIVES.—With but slight exception, the individual motor drive has been applied to all of the machinery throughout this plant, and even the most casual observer cannot fail to notice the simplicity and compactness of the power-transmission arrangements, and the freedom afforded the machinery and spouting arrangements by the absence of line shafting, belting and other equipment incidental to mechanical drives.

The low load factor of an individual motor drive in elevator and conveyor service demands motors of small rated and heavy overload capacities, for commercial success. The induction motor has suitable characteristics and by careful attention to starting operations the sizes may be kept down.

It is probable that the motor equipment installed in this plant has the smallest rated capacity in proportion to the capacity of the grain handling machinery of any comparable plant in existence. The aggregate rated capacity of the motors installed is 2,215 HP. of which 1,045 HP. is distributed about the top floor of the elevator. With the exception of the passenger-elevator drive, the motors are all three-phase, 440-volt, 60-cycle, squirrel-cage rotor types of standard design and construction.

REMOTE MOTOR CONTROL.—Undoubtedly the most interesting feature of the whole installation is the method of motor control. The necessity of providing for the remote control of many of the motors, together with other conditions of grain-elevator operation required to be met by the electrical equipment, rendered desirable the locating of all of the switching arrangements at one point, and the placing of the switches under the control of an attendant trained for the work. The motor starting is performed solely by this attendant, while the motors can be stopped by pressing a number of push buttons, which are conveniently located throughout the plant and are connected to independently-excited trip coils operating proper switches. Each motor in the plant has an independent set of feeders and a separate control switch. All of these switches are mounted upon a switchboard, which has two sets of bus bars, one set for the main or running potential, and the other for the compensator or starting potential. The bus bars are connected to two compensators through a combination of switches, which permit of the compensators being used either independently or in multiple, and furnishing either 40% or 50% of the main potential to the compensator bus bars. The motors are connected first on to the low-potential and then on the running-potential circuits, by double-handle switches. These switches lock on the running side, but not on the starting and only one side can be closed at a time. Each has three trip coils, two for overload release and one for the remote-control release alluded to.

The elevator or conveyor operators signal to the switchboard operator, by a push-button and annunciator-signal system, which motors are to be started. Return signals are similarly made through push buttons over the starting switches and bells, near the corresponding motors, indicating that the starting operations have been completed and that load may be applied (by throwing in a friction clutch). The decrease of the starting current with the increase in the speed of the motor is taken advantage of to furnish a means of indicating to the operator when to make the transfer from the starting side to the running side of the switch. Each motor circuit is provided with an ammeter, having the scale graduated proportional to the load percentages. The ammeter is in circuit only when the switch is closed on the starting side.

The average time required to start a motor is 35 seconds. The remote control switches for the ten motors, which operate the belt conveyors in the wharf-conveyor system, in addition to being subject to the individual remote control previously referred to, are subject to a collective remote control, the purpose of which is to shut down the entire shipping system in case of an emergency. The remote-control trip coils of these switches are connected to the contact studs of an automatic, adjustable time-element, multiple-contact switch. This switch is brought into operation upon pressing any one of about 60 push buttons, which are located at the wharf loading spouts and in the towers. The connections to the contact studs are made in such order, and the time element is so adjusted, that the motors stop in an established sequence. This arrangement is to prevent the discharge of grain from a moving belt conveyor to a stationary one ahead of it. Less than ten seconds are required to bring the entire shipping conveyor system to a standstill.

The auxiliary systems required for this whole scheme of motor control require 48 annunciator

*Description prepared for the General Electric Co. by Mr. Cecil Hodgson, Assoc. Am. Inst. E. E., Electrical Engineer, The Witherspoon-Englar Co., Monadnock Block, Chicago.

drops, 63 bells and 247 push buttons variously connected to 140 independent circuits. The artificial lighting comes from 16-c.p. incandescent lamps of which there are some 800 distributed about the plant. The switching room and the superintendent's and weighman's offices are heated by electric radiators.

A 32 station inter-communicating telephone system with extension bells provides communication between the widely scattered operators throughout the plant. A noticeable feature is the use of a flexible, pivoted, metallic arm for the receiver, which falls back into place and resets the telephone after leaving the hand, making it impossible for the operators to leave the telephone so that the next caller gets a "busy" signal, with the telephone actually not in use.

Signals are transmitted from the scale floor to the first floor and vice versa, in connection with the operation of the elevators, by means of a colored-lamp signal system. Each elevator is provided with a red and blue lamp on each of these floors, the lamps of the same color being connected in series and controlled by three way switches.

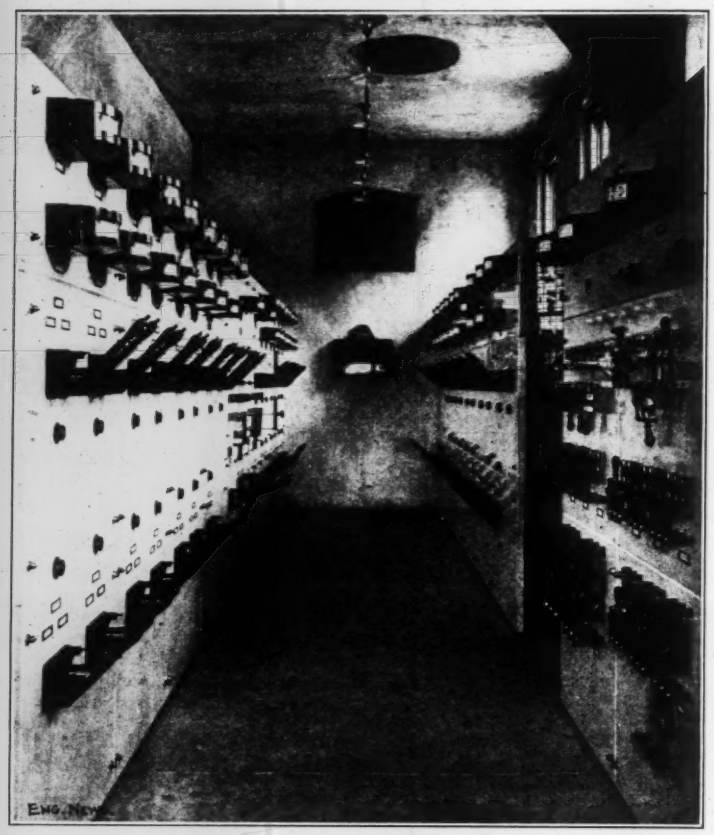


FIG. 2. SWITCHING ROOM FOR CONTROL OF ELEVATOR AND CONVEYOR PLANT OF THE BOSTON & ALBANY R. R.
(Showing motor-starting, lighting and signal system panels.)

There is something like 70,000 ft. of wire of various sizes distributed about the plant and all circuits are run in galvanized conduit. Current is furnished by the Boston Edison Electric Illuminating Co. The three-phase supply for the motors has a nominal voltage of 440. For lighting and auxiliary service, single-phase current is supplied at a regulated potential of 230 volts. The signal systems and the telephone-ringing circuits operate on current, at 75 volts, obtained from small transformers on the lighting circuit.

A pumping station for water-supply and fire protection is maintained in connection with this plant but operated independently, the machinery being installed in a separate brick building. There are two 1,500-gal. fire pumps, each having a capacity sufficient for six 1⅛-in. nozzles, when working against a pressure of 125 lbs. These pumps are a two-stage turbine type direct-connected to a 200-HP. three-phase induction motor having a wound rotor and slip rings so that it may be started under load.

A 150-gal., two-stage turbine pump is driven by a 25-HP. motor to keep the main tank full. The motor has a wound rotor with slip rings for starting loaded. The operation is controlled by a float switch in the main tank.

The entire electrical equipment was laid out by the general contractors and engineers, the Witherspoon-Englar Co. Sub-contracts were let to the General Electric Co., for the motors, and to the Lord Construction Co., of Boston, for the electrical construction about the plant. The fire pumps were installed by the Platt Iron Works.

Ellen Henrietta Richards.

By C.-E. A. WINSLOW.*

Ellen H. Swallow was born at Dunstable, Mass., Dec. 3, 1842. She graduated at Vassar College in 1870 and at the Massachusetts Institute of Technology in 1873. In 1875 she married Robert Hallowell Richards, and in the next year she began her career as instructor at the Massachusetts Institute of Technology, where she and her husband (now head of the Department of Mining Engineering) have taught side by side for thirty-five years.

Mrs. Richards was fortunate in beginning her work under the brilliant direction of William Ripley Nichols, who was at that time laying the foundations for modern exact study of sanitary problems, and when Thos. M. Drown began his classic studies of inland waters for the State Board of Health of Massachusetts in 1887, an unusual opportunity came to her in the administration of the laboratory organized for that purpose. Since that time Mrs. Richards has been a recognized leader in sanitary chemistry. Her book on "Air, Water and Food, From a Sanitary Standpoint" (with Prof. A. G. Woodman) is a standard laboratory manual, and two more recent works, "Laboratory Notes on Industrial Water Analysis" and "Conservation by Sanitation" are important contributions to the same subject. As chemist to the Manufacturers' Mutual Fire Insurance Co. she has also made extensive studies of the chemistry of oils, with reference to the danger of explosion.

Mrs. Richards is best known to engineers as a teacher of sanitary chemists. From the laboratories in the Walker Building, where the traditions still linger of the pioneer days when the first extensive series of water samples were there analyzed, and when the famous first "chlorine map" of Massachusetts was prepared, there have gone out, year by year, scores of chemists, biologists and engineers who owed their training in "air, water and food" to Mrs. Richards. Many of the leaders in their professions are among this number and they remember with warm affection the personal guidance and inspiration of their instructor, cheerfully critical and full of enthusiasm tempered by the wisdom of experience.

Mrs. Richards' great work in the world was, however, in a somewhat different field, as a leader in the movement for the education of women and for the introduction of the spirit of science into the primitive industry of home-making. She lived at a critical period for women when the possibilities and the responsibilities of life suddenly broadened and deepened for them in an unprecedented degree. She saw clearly that the highest and fullest scientific education could alone meet the demands of the time, and to this cause she gave herself with remarkable ability and unsparing vigor. A score of suggestive and enlightening books on the "Cost of Living," the "Cost of Food," the "Cost of Shelter," the "Cost of Cleanness," "The Chemistry of Cooking and Cleaning," "Food Materials and Their Adulteration" and "Home Sanitation" testify to her activity in these directions. At Columbia University, at the University of Chicago, at the University of Illinois—wherever the economies of the household are taught and studied—Mrs. Richards is looked up to as a pioneer. What her personal counsel has meant to the women of Vassar and the women of Technology, to college women everywhere, no one can tell. Dean Talbot, of the University of Chicago, said in a recent tribute:

> Your courageous words have many times served as a clarion call to women to hew out new paths and to press on to meet the increasingly difficult duties civilization is placing upon them. Your gentle words of encouragement have many times helped them to keep to the path. Your silence and your patience have in their turn served to give time to the laggards to find the path and join the advancing host.

Mrs. Richards died March 30, 1911, full of years and honors and achievements. She was busy with many-sided activities up to the last. The most extensive of all her books, "Conservation by Sanitation," bears the date 1911. She received the honorary degree of Doctor of Science from Smith College on Oct. 5, 1910; and on Jan. 7, 1911, the women of the Institute of Technology presented her with a research fund as a token of their appreciation of her distinguished service. The presentation speech, conferring the honorary degree at Smith College, summed up her career as follows:

> Bachelor and Master of Arts of Vassar College, Bachelor of Science of the Massachusetts Institute of Technology, and there for over a quarter of a century Instructor of Sanitary Chemistry. By investigations into the explosive properties of oils, and in the analysis of water, and by expert knowledge relating to air, food, water and sanitation, and the cost of food and shelter, set forth in numerous publications and addresses, she has largely contributed to promote in the community the serviceable arts of safe, healthful and economic living.

*Associate Professor of Biology, College of the City of New York, until recently Biologist-in-Charge, Sanitary Research Laboratory, Massachusetts Institute of Technology.

THE RUSTING OF STEEL IN CONCRETE has been made the subject of an investigation by the Concrete Institute, of England. The preliminary report on the subject is as follows:

A circular letter was issued at the beginning of 1909 by the Concrete Institute, asking for the results of experience and examination on the question of whether rusting of steel takes place when covered by concrete. The letter was sent to 1,000 engineers and others engaged in concrete construction—namely, to members of the Concrete Institute, 560; to municipal surveyors and engineers, 96; to engineers of joint water boards and sewerage boards, 25; to dock engineers, 38; to railway engineers, 94; to various contractors and others who use concrete, 187. To this letter 111 replies were received. Forty-seven contained results of definite observations. In these the writers gave 26 cases of rusting which had come under their notice, and 43 cases where no rusting has been found.

The committee considered that the information thus gained was extremely valuable, but, in order to obtain more definite knowledge of the question, they personally examined certain structures.

As a result of these observations and investigations, the committee have drawn the following conclusions. Reinforced concrete will last as long as plain concrete in any situation provided that certain special precautions are taken during its construction. The precautions to be taken are as follows:

CONCRETE.—The materials (cement, sand and stone) must be of good quality. They must be most carefully and thoroughly mixed and scientifically proportioned, so as to be practically waterproof and airproof. The mixture must be fairly wet and must be well punned into position so as to minimize voids. The aggregate should be as non-porous as possible, and any aggregate which is known to have a chemical action on steel should be avoided. The aggregate should all pass through a ¾-in. mesh. The concrete covering should in no case be less than ½-in., and it is suggested that if round or square bars be used the covering should not be less than the diameter of the bar. In structures exposed to the action of water or damp air the thickness of covering should be increased at least 50%, or the size of the aggregate should be reduced so as to ensure a dense skin. In the case of structures exposed to very severe conditions, the concrete might be covered with some impervious coating as an extra precaution.

STEEL.—The reinforcement should be so arranged that there shall be sufficient space between one piece and its neighbor to allow the concrete to pass and to completely surround every part of the steel. All steel should be firmly supported during the ramming of the concrete, so as to avoid displacement. It should not be oiled or painted, and thick rust should be scraped and brushed off before placing.

GENERAL.—The scantling of the various members of the structure should be sufficient to prevent excessive deflection. If electric mains are laid down, very great care must be taken that no current is allowed to pass through the reinforced concrete. Fresh water should be used in mixing, and aggregates charged with salt should be washed.

These recommendations have regard only to the prevention of corrosion of steel and not to fire-resistance or any other property of reinforced concrete.

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Although the Baltimore "News" reinforced-concrete building, now being torn down, is not old enough to verify those claims of eternal life often made for construction of that type, it is still the oldest and largest example of the modern reinforced-concrete structure whose "insides" have been exposed to critical view, and, for comparative purposes at least, there are lessons to be learned from its present condition after about seven years of use. Nothing has developed from the examination of the structure that will lead to any radical revision of current practice. The lessons are, therefore, not new, but the added authority gained by observed behavior probably warrants their repetition.

Briefly stated, an examination of the "News" building shows that loosely laid rods are very apt to become seriously misplaced; that high percentages of reinforcement will result in rods in contact with each other; that concrete-encased steel remains perfectly clean and bright under normal conditions, and, finally, that where water penetrates the concrete, the steel will rust.

The first two of these items have been the subject of numerous warnings in the past. Common sense and an intelligent reading of drawings will show them to be true, but the sections of beams and girders on the Baltimore building, packed full of misplaced metal, bring the truth home to an observer as argument and theory never could.

The matter of rust is more important. The question of the behavior of steel encased in concrete has worried engineers ever since the introduction of reinforced concrete. Unfortunately, it has been settled offhand too frequently by those whose wishes have fathered their opinions. In this country, however, we think the general impression is that the steel of reinforced concrete is safe against the attacks of rust, except in cases of extreme porosity in the concrete. The leaky condition of certain water-holding concrete structures which we call to mind is evidence that some men are not afraid even to let water pass through their reinforced-concrete structures. In England, however, the characteristic conservatism has led the Concrete Institute there to conduct an investigation through inquiries to a number of men throughout the world, into this question of rust. A short resume of this investigation is given on page 418 of this issue. Both the spirit of doubt that was behind such an investigation and the answers which were received from it show that the rust question is not fully settled in the minds of English engineers.

Be that as it may, the structure of the "News" building at Baltimore shows that with concrete not at all of an exceptional mixure—concrete, in fact, which would be expected in any concrete building to-day—the reinforcing of steel is perfectly safe against deteriorating rust, except where water percolation exists. As to just when such percolation may be expected, the present example does not help, for inasmuch as the larger part of the rods and of the grillage beams in concrete subjected at times to water do not show any rust, it is fair to assume that there were locations where the composition or the manufacture of the concrete was below the average, and at these places percolation took place and the rusting started. Unfortunately, the period of use has been too short to predict what may be expected elsewhere under similar conditions, but evidently in this case, through minute openings which appeared in the concrete, the water or the moisture passed clear from the outside to the steel surface, causing the pits of rust. The time has been too short to predict whether the continued action would have caused these openings to grow or would have finally brought about the characteristic swelling of the metal and final disruption of the concrete.

Enough did occur to show the necessity of constant vigilance in concrete laying in order that a uniform material may be procured. As to the effect of rust, we would much like to see a section cut through a reservoir or stand-pipe reinforced-concrete wall that had been leaking for some time. The condition of the rods there would show us the state of affairs in structures where structural weakness from rusting might be expected. In a skeleton concrete building, protected from weather or plumbing leaks, the danger from this source would certainly seem to be very small.

When a manufacturing company is about to construct a new plant, its criterion for original expenditure is based on the sum of the annual charges of interest on the capital to be invested, of maintenance and of a sinking fund to pay for the replacement in a given term of years. The type and quality of construction that will yield best results with these items as plant charges, fixed independently of gross production, is generally selected. On another page of this issue Mr. R. W. Wetherill suggests a new item which is often forgotten in this assumption of justifiable first cost. He maintains that a permanent construction which entails no worrisome attention to the details of repairs and replacement on the part of the directing officers leaves to those officers a certain amount of time and energy which can be converted into profitable returns. In any preliminary estimate he thinks these added returns should be capitalized and be placed to the credit of the permanent construction.

Undoubtedly, there is a valid basis for this argument, but it suffers from a too intangible application. The premise that anything that relieves the directing head of routine or petty labor tends towards efficient management and consequently increased returns may readily be accepted as a general assumption, but its application to a concrete case is most indefinite, and its conversion into dollars and cents for relative preliminary estimates a matter of extreme difficulty. The argument also involves the less apparent assumption that good men are so scarce that it is cheaper to build a costly plant not needing any attention than to employ a man solely to look after the maintenance of a plant of lower first cost, leaving to the master mind the time and energy to work out his schemes for future business increase. This is an extreme generalization. Is it not fair to assume that the worthy subordinate is equally as possible as the managerial genius? Can we not reasonably suppose that there are as many men capable of relieving the superior from the cares of maintenance as there are superiors of such brilliant capacities that by slight extra concentration of mind they can make two thousand grow where but one grew before?

There is danger that too great importance be given permanency of construction. Sight should not be lost of the fact that there is no such thing as permanency in human affairs. Man can erect structures or create works that intrinsically are eternal, but their uses must always be transient. The ever-changing nature of both man and his methods makes it impossible that his creations should serve the purpose for which they were created beyond a somewhat limited term of years. With the wonderful progress that invention makes, there is no justification for the expectation that what we are using to-day will be of the same use 20 years from to-day.

In any construction where mechanical devices or processes are involved, or where needed capacity is increasing, care must be taken lest it be outgrown before it is outworn. Examples of this are all around us, but a recent incident, noted in this issue, will suffice as an illustration. In the city of Baltimore to-day there is being torn down a seven-story reinforced-concrete building only seven years old, to be replaced by a 18-story steel structure. For the site where it was erected, in the heart of the city's business center, there was no justification for so permanent a construction in such small size as a seven-story building. Both in the extra original cost and in the very high razing charges, the owners are now finding that out.

The above arguments have only limited application in construction which is not designed to bring in direct returns on the investment, or in static structures, such as buildings and bridges, where no need for a decided increase in capacity may be expected. Under such conditions absolute permanency is not to be despised. In a producing plant, however, the desirable lifetime of the essential elements of the plant is governed entirely by their probable future usefulness, and where permanent construction is recommended, experienced judgment, combined with a fair talent for prophecy, must determine what this permanency means. It is probable that the directors in making preliminary estimates of such new work will balance against the possible, but indefinite, profits which may accrue from their undivided attention, the equally possible and indefinite expenses which may be necessary to reconstruct a too permanent plant when it has become out of date.

The New York "Times" of March 31 comes out in favor of the McGrath bill for licensing engineers and makes a sage guess as to why the leading men in the engineering profession oppose such legislation. Its guess is amusing enough to go on record:

> When the Legislature gets to work again, the McGrath bill compelling civil engineers to take out licenses before following their profession in this state ought to receive the serious attention it deserves.
>
> A good deal of antagonism to this measure has been expressed by engineers and in the technical papers. There seems to be, however, reason for thinking that most of the opposition to extending thus the system of licenses based on examinations by a competent state board is due to misunderstanding of the bill's provisions or complete ignorance of what they are.
>
> Naturally enough, some of the engineers are inclined to resent the implication that not all of them know their business, but those who know it would hardly deny that such is the case, and of course for none of them would there be any more loss of dignity in submitting to an examination and taking out a license than there is for the members of other professions when they do the same or analogous things.
>
> The justification for subjecting civil engineers to treatment to which doctors, teachers, and lawyers submit with equanimity is the extent to which public interest and safety depend on their competency and skill—an extent which increases with every year that passes. Apparently the justification is adequate, and the McGrath bill easily defensible from any attack as yet made upon it.

To suppose that engineers are opposing the bill because "they resent the implication that not all

engineers know their business" is to suppose an absurdity. The engineers are well aware that there are plenty of incompetent and unreliable men doing engineering work and they oppose the license system because they do not believe it would have any material effect in keeping out such men from positions of responsibility. It would, therefore, tend to mislead the public with a false sense of security and at the same time would impose a needless and serious burden upon the competent engineers in all branches of the profession, greater by far than that imposed upon the members of any other profession which is controlled by law. The burden is greater because the average engineer would have to pay license fees to several states; and the leaders of the profession, whose consulting practice extends over a wide area, would be subjected to great annoyance and expense, if they had to take out a license in each state where they did work.

The "Times" editorial has been effectively answered by Mr. Frank J. Sprague, and we reprint portions of his letter, as follows:

Editor, New York Times:

If I may quote your own words I think your attitude on the McGrath Bill for Licensing of Civil Engineers must be "due to misunderstanding of the bill's provision or complete ignorance of what they are." In view of the fact that the "Times" had no representative at the recent hearing, that characterization of your knowledge of the subject is far more pertinent and accurate than when applied to the engineering press, and to the large body of representative engineers who appeared in Albany in opposition to this bill, and who had made a specific study of its conditions.

Ignoring for the moment any discussion of the general principle of licensing of engineers, concerning which any possible bill should be of National scope and the result of consultation on the part of the various reputable engineering societies and educational institutions, it is well to look into the genesis of this McGrath bill. It is practically the same bill as the Raldiris bill which appeared at Albany last season, and was introduced by the same interests. Its sponsor is what is known as the "Technical League of America," whose president is one Walter G. Elliot, reported to be an engineer in the employ of one of the city's departments. In a pamphlet submitted, this was described as a "United States Organization of Civil Engineers," and the attorney representing the bill claimed that it was an organization of "all America."

At the hearing, the sole representatives of the League were this Mr. Elliot and his attorney, Judge Dahahar. It now seems that the Technical League is an insurgent offshoot of the Municipal Engineers, and is a secret organization which apparently includes in its membership minor employees engaged in municipal departments, but no member has the right to know who any other member is. A total membership of perhaps a thousand is claimed, of which 250 were in the state of New York, which meager claim is probably overstated. Neither the city directory nor the telephone directory discloses the Technical League nor any of its officers. It has no constitution or by-laws and, as stated, no public membership list. Although an office is claimed in the Park Row Building, the directory is innocent of announcement; and the pamphlet supporting the bill was said to be issued by order of the "Executive Committee of the Technical League, by its President," who gave the street address of the University Club. This gentleman, I believe, is not a member or an associate of any of the National Engineering Societies, all of whom, of course, publish their membership.

In Albany the opposition to the McGrath bill was represented by Presidents or Past-Presidents of all the leading engineering societies, as well as by spokesmen for the state's great universities. The membership alone of these societies is over 20,000, and a quarter of these members are in the state of New York. All these men ask for is an open field to practice their profession and they wish no trade union bars. They are able to take care of themselves, and they welcome the entrance of competent engineers of other states, while claiming the equal privilege of carrying on a business which is world-wide, unhampered by paternal restrictions in this or any other state.

In no profession in the world is a man's employment so carefully predicted upon proven education and experience, determined by employers who have every facility for making investigations, and in none will a man so certainly fail if he proves incompetent. His business is essentially individual with his employer, and it would be more than folly to grant by license obtained on a limited examination a general privilege, under the aegis of the state, for carrying on a profession having a hundred branches.

Frank J. Sprague,
Past-President American Institute Electrical Engineers.

The Latest Object Lessons Concerning Fire Dangers.

The terrible fire of March 25 in a shirt-waist factory on Washington Place, New York City, in which nearly 150 persons lost their lives, has aroused public opinion in New York City to a remarkable degree. On Sunday, April 2, overflowing public meetings were held in the Metropolitan Opera House and in the Grand Central Palace, and the keynote of both these meetings was the demand for the passage of new laws to furnish better safeguards against fire, and the provision of adequate means for the enforcement of these laws.*

What these laws should be, and what means should be provided for their enforcement, was little touched upon at the meetings; but a pregnant word was spoken by Prof. E. R. A. Seligman, of Columbia University, who said in his address, "What we need is the immediate employment of experts." The same idea was expressed by Comptroller Prendergast, who remarked that new legislation, no matter how well planned, would be ineffectual unless its enforcement was placed in the hands of those who understand the subject and unless inspectors are selected because of their experience, ability and expert knowledge and not because of political pull.

It seems worth while, therefore, to say a word in this place as to what the engineer can do for the community, if he is given the chance; for it is at times like these that the community realizes its need of the engineer—the real Engineer.

And right at the start we run against the difficulty that the community does not yet sufficiently realize how much it needs the engineer. It realizes it to-day, in the shadow of a great calamity; but it will forget it a month hence. To-day the public seems to demand that such holocausts as the Washington Place disaster be made impossible; but by the time the engineer presents his estimate of what that will cost, in dollars and cents, the public is reading the latest murder mystery or the base ball news, and the man who pays the money says, "Oh, I guess we'll just do the most important things and leave the rest. I'm doing as well as my neighbors now."

The New York "Tribune" in its issue of April 3 says that since the Washington Place holocaust occurred, many manufacturers renting workrooms in loft buildings have sent complaints to the Building Department that the buildings they occupied lacked outside fire-escapes. But many of these very complainants are shown by the Bureau's records to have long been themselves persistent violators of ordinances requiring doors leading to the ordinary staircases to be kept unlocked, and passages to such doors to be kept unobstructed.

In its present state of temper the public is ready to lynch anyone whose neglect causes a holocaust. Bishop Greer in the Metropolitan Opera House on Sunday declared that New York needed a Bureau of Fire Prevention, "to be a sort of vigilance committee and do in its field just what the old Vigilance Committee of San Francisco did."

But for every single factory where a Washington Place disaster occurs there are a thousand or ten thousand others where conditions just as dangerous are maintained by owners and tenants, and nothing happens. It is not justice to punish the one man whose neglect combined with chance causes a disaster and let ten thousand others quite of equal neglect go free.

Turning now to the question which the public just now is seriously asking the engineer, how such calamities may be prevented, it will be instructive to go back a little and review the origin of the present day high buildings.

It is within the memory of men still young that New York has grown from a city of four and five-story buildings to a city with ten and twelve-story buildings. The introduction of fireproof building construction 20 years ago and of the elevator, combined with increasing values of real estate, have not merely caused but compelled an enormous investment in the construction of high buildings.

In the early days of fireproof building construction, their safety as respected their occupants was greatly overestimated. It was felt that a structure which was incombustible was so great an advance over the flimsy fire-traps which had preceded it that the risk to its occupants was practically eliminated.

The disasters which have befallen many fireproof buildings of first-class character within the past score of years has shown how false was this supposition. It is well understood now that in every fireproof building *the combustible character of the contents*, even in buildings occupied solely as offices, is sufficient to feed a serious fire, which will rapidly spread unless prompt measures are taken to hold it in check.

In the early days, also, the fireproof high buildings erected were designed solely for office use. The changed conditions when these buildings were adopted for stores, for factories and for warehouses were not appreciated at first; and by the general public, indeed, are not appreciated to this day.

It is hardly realized even yet that to say a building is fireproof means nothing more than that the structure itself can pass through a fairly serious fire with only a moderate amount of damage and that such a building really offers little additional security for the goods it contains or the people who occupy it if no other precautions against fire are taken. Safety for the occupants must be sought through other means. This may seem so simple and elementary a fact as to be hardly worth stating, yet the public, and even the intelligent portion of the public, still fails to comprehend it.

It seems to be thought that there is little necessity for outside fire-escapes on fireproof buildings. As a matter of fact, such escapes may sometimes be more useful than on a fire-trap. In the fire-trap the chances are that the occupants will be burned up before many of them can reach the fire-escape. In a fireproof structure, with some moderate amount of subdivision, there should be time for the escape of a reasonable proportion of the occupants at least.

The fires which have occurred in theaters, schools and assembly halls within recent years have been object-lessons from which the public has gained some comprehension as to the dangers of collecting large crowds of people on upper floors of buildings from which exit can be gained only by narrow or winding staircases. The Iroquois Theater fire was a remarkable object-lesson, showing how even on a ground floor slight obstructions in the exits could pen a large crowd and hold it imprisoned long enough to cause the

*The resolutions passed by the Metropolitan Opera House meeting were as follows:

Whereas, It should be realized that the Washington Place disaster was due to neglect on the part of the whole community; and whereas a repetition of the calamity can be prevented only by the citizens doing their part in securing the enactment of effective laws and their stringent enforcement;

Therefore be it Resolved, That while we call upon the city officials to exercise immediately all their powers under the building code to require that all factory and loft buildings be put into a safe condition, and to make an adequate increase in the number of inspectors, invoking if necessary the peremptory power of the Board of Health;

That we call upon the Legislature immediately to create the Bureau of Fire Prevention, recommended by the Fire Commissioner;

That we petition the Board of Estimate to make sufficient appropriation to enable the Fire Department to develop immediately the work of fire prevention;

That we ask the Board of Aldermen not to relax the fire rules against overcrowding and standing in rear aisles in theatres and moving-picture shows, and to adopt similar rules requiring sufficient aisle space for access to fire exits in stores, factories and work shops;

That we recognize as fundamental the following safeguards: Compulsory fire drills, adequate fireproof exits, unlocked doors opening outward, fire alarms, automatic sprinklers, regular inspection and testing of apparatus;

That we commend to employers and employees the plan now in operation in the cloakmaking industry, giving power to a joint board to inspect factories and to enforce the standards of safety;

That we favor as the most effective means of preventing accidents to working people the plan which invokes the self-interest of employers by a system of workmen's compensation, such as is in force in other civilized countries.

That the Mayor of New York be asked to call a conference on fire prevention, extending invitations to Mayors, fire chiefs, and fire experts throughout the country.

That the Chairman of this meeting appoint a committee of five with power to cooperate with other organizations and committees to appoint a permanent committee to the end that there may be a continued effort to secure hese vital requiremnts.

death of hundreds through suffocation by smoke and trampling to death in the panic.

The disaster in a Newark factory a few months ago, followed by the Washington Place holocaust, are illustrations of the fact that a crowd of factory employees housed on the upper floors of a building are just as liable to danger from fire or panic as if they were in a theater or auditorium.

This again seems so simple and obvious a fact as to hardly need stating; yet there are a hundred or a thousand factories in and around New York City to-day, and without doubt in fifty other American cities as well, where the conditions to make possible another Washington Place horror are all present as soon as the fire shall break out. Any one who visits and views with the eye of an expert almost any of the crowded department stores during the holiday season, and in certain hours during a large part of the year, can appreciate the conditions which fire or panic would promptly bring about in any of these structures. The wonder is not that such disasters as that which filled New York with horror on March 25 occur. The wonder is that they come so rarely.

What can be done to prevent such disasters? The first and the most radical remedy that needs to be named is to prevent the carrying on of industries employing large numbers of work people in a small space on the upper floors of any high building. If it is argued that with present prices of metropolitan real estate this is financially impossible, the answer is that such industries ought to be carried on in the country, where land is cheap, and it is no more expensive but rather less expensive to build factories of two or three stories than it is of eight or ten. In a building of two or three, or even of four, stories, surrounded by wide open spaces, it is practicable to provide outside exits leading directly to the ground, of sufficient number and size that the risk to those employed in the building in case of fire can be practically eliminated. Of course, some qualifications should be made even upon this. The character of a building should depend upon the risk involved in the work carried on within it. One would not put a celluloid factory, for example, on the third or fourth story of a building in any event, and subdivision by fireproof partitions is advisable in many cases, whether the building is located in the city or in the country. Lack of public fire protection in the country may increase the danger there.

We believe any engineer asked to provide a factory building which should make its employees safe against dangers of fire and panic would invariably locate the factory in a suburban or country town rather than in a densely crowded city. It may be said, however, that this is aside from the question and that we must provide means by which the buildings now erected and others to be erected in the densely crowded centers can be made reasonably safe.

This problem, also, the engineer can solve, but he must be given a free hand. He would in the first place provide every workroom, such as those in which the disastrous fire of March 25 occurred, with automatic sprinklers. He would provide other abundant means of fire protection additional to these, and would see that a water supply was afforded for them independent from that used for the ordinary purposes of the building, which might be wanting in case of need. He would see that the interior area was properly subdivided to check the spread of fire across a large area and to give additional time for employees to escape. He would, further, limit the number of employees that might be concentrated in a given area, and would proportion the means of exit provided to the number of employees.

It may be objected that all this would make the occupancy of such buildings too costly; but the proper answer to this objection is that the effect of such restrictions would be to induce the removal of the manufacturing industry to the country and the suburbs, which is exactly where it belongs. Such a change might, indeed, reduce the value of real estate and ground rents and bear hardly on their owners, but, as was emphatically expressed in the public meetings held last week, the safety of life ought to be more sacred than the safety of property.

Quite a different problem is presented by the disastrous fire which wrecked one wing of the New York State Capitol Building at Albany last week and destroyed, among other things, an enormous number of manuscripts and original records of priceless historical value. We mince no words in saying that such a fire is absolutely without excuse. The best that can be said in extenuation is that at the time the Capitol was built the art of fireproof construction had not advanced to any such stage as it has attained to-day. Even at that time, however, it was within the ability of the engineer to do very much better and safer work than was actually provided.

Both then and now, however, the public in planning and building is wont to place all its reliance upon the architect; and the great architects, who produce our public buildings, in nine cases out of ten are artists primarily and not constructors. The sins of which architects are guilty in lavishing money on ornamental exteriors, affording to the eye every appearance of solidity and permanence, behind which are placed all manner of combustible and perishable materials arranged in such a manner as to best favor the spread of flames, would horrify the public if it knew the facts.

The architects of the Albany State Capitol and other state capitol buildings which have burned to the ground within recent years simply did what their contemporaries did—provided handsome exteriors and left the American carpenter, with his wooden studding and lath partitions, to lay a foundation for future conflagration.

Whatever excuse there may have been for such work in the past, there is absolutely none at the present day. Every building intended to house permanent records ought to be made absolutely and wholly incombustible; yet even in the best of them the old habit still persists of providing convenient wood furring and wood decorations to produce the ornate effect in which the architect chiefly glories.

Since the fire in the Albany Capitol occurred and the news came of the destruction of valuable records there, Mr. Robert B. Stanton, M. Am. Soc. C. E., in a letter published in the New York "Times" of April 1, has called public attention to the introduction of combustible materials in parts of the new Public Library building in New York City, which is to house one of the most valuable collections of original documents possessed by any library in the world. Mr. Stanton declares that in this building liberal use has been made of wooden ceilings, wooden cornices and wooden foundations on which to support electric wiring conduits. To start a fire in this combustible material—much of it resinous pine—all that is necessary is a short circuit in the maze of electric wiring which runs through it. It is true, the amount of wood is not sufficient to cause a conflagration or to injure the structure of the building itself, or to even endanger the occupants, but even a moderate fire, with the attendant volume of smoke, may bring in the fire department to pour on tons of water in the endeavor to extinguish the flames. The consequence may be the destruction of many valuable documents by the combined effects of fire, water and smoke. In the published reply made by the architects of the building to Mr. Stanton's criticism, absolutely no defence is made except that the electric wiring is perfectly safe because it is carried in insulated iron pipes!

We have called particular attention to this recent statement regarding the New York Public Library because it expressed the main point we wish to emphasize—that the public must look to the engineer, and not to the artist, if it desires and is willing to pay for absolutely safe construction. In the hands of the engineer the art of building has now progressed to a point that a structure absolutely incombustible in all its parts and in all its finish is entirely practicable. Such structures should be provided wherever such valuable treasures have to be housed as those which our great libraries and many of our government departments possess.

LETTERS TO THE EDITOR.

The Compensation Received by the Railways for Carrying the Mails.

Sir: An article on p. 232 of Engineering News of Feb. 23, 1911, entitled "More Concerning Postage Rates on Publications and Railway Mail Pay," contains some statements and comparisons tending to show that the railways are being overpaid, which I am sure were made through a misunderstanding of the true relation of the railroads to the subject of Railway Mail Pay and without possession of complete information as to the service they are performing for the Government and the compensation they are receiving for doing it.

In justice to the railways I would ask if you will not publish in your columns the following, so that the railway side of this question may be placed before your readers:

The article in question, after briefly mentioning the evolution of the present rates of Railway Mail Pay, states, with reference to the original law passed by Congress,

> The underlying idea was that the faster service furnished by the railway might be paid for at a higher rate. It was not realized that the great reduction in cost of transportation effected by the railway was a benefit which the public was entitled to share.

The history and statistical records of the carriage of mails by the railroads shows that the Government has shared in lower rates from the railways to a greater extent for carrying its mails than has any other railway patron. The faster and more frequent service which is now given by railways in transporting the mails, is compensated by lower instead of higher rates than formerly.

The reduction in rate is automatic. As traffic increases, the rates paid the railroads per unit of transportation decrease, even during periods of high cost to the railways for labor and material and when because of this reason rates for passengers, express and freight may be stationary. At the same time the railways cannot reduce the cost of mail transportation to themselves in anywhere near as great ratio because economies through heavier car loading cannot be practiced due to the very light load that can be carried in a postal car because of its post-office features, space for mail clerks, etc.

During the past twenty years average rates per ton-mile paid the railways by the Government have decreased 40%, while rates paid railways by the public for freight have decreased 17% and for passengers 11%. During the past ten years when labor and material costs to the railways have been increasing, average mail earnings of the railways per ton mile have decreased 26% while average passenger and freight rates have slightly increased.

The article in Engineering News holds that the railways are being overpaid for railway postal cars, the statement being made that a full postal car, paid for at $40 per mile per annum, run every day over a route 500 miles long, will earn the railway $12,000 a year. This statement should be reduced at least one-half as the $40 rate calls for service *in both directions* and not in one direction as has been assumed.

The 1910 report of the Postmaster-General shows that the railways received as postal car pay $4,686,122. The Second Assistant Postmaster-General, in his report, says that on June 30, 1910, there were assigned to railway mail service, including cars which the railways had to have in reserve on account of necessity for shopping cars for repairs, etc., 1,320 full postal cars. This means that the average actual revenue received by the railways for each railway postal car furnished was only $3,550 per annum. The railways also furnish the Department, according to the report of the Postmaster-General, 3,767 apartment cars for which *no additional compensation* is received and of which fact no mention is made in the Engineering News article.

The average length of postal space in these apartment cars is 46% that of full cars. These cars therefore represent the equivalent of 46% of 3,767, or 1,733 full postal cars. Thus the railways furnish post-office car space equal to 1,320 plus 1,733 or 3,053 cars, for which they receive postal car compensation amounting to $4,686,122, or only $1,535 per car per annum.

The Chairman of the Inter-state Commerce Commission, after investigating the subject, reported to Congress under date of Feb. 2, 1911, that a steel postal car cost from $9,500 to $10,500, or say an average of $10,000; that the average cost of maintenance per annum was about $1,225 using gas for lighting; figuring interest, taxes and depreciation at 10% on the investment would add $1,000, making a total of $2,225 per car per annum required by the railroads to pay the direct cost of maintenance of cars and interest on investment, allowing nothing whatever for the cost of hauling.

The Engineering News then compares the erroneously stated earnings from postal cars with rental rates paid railways between themselves for similar equipment of three cents per mile. A postal car averages about 100,000 miles per annum and this rental rate would amount to $3,000, or more than the railways receive from the Government for renting and hauling postal car facilities.

The very grave error has been made of comparing a rate for rental alone paid by a railway for the use of a postal car owned by another railway, with a rate paid to the railroad by the Government for the use and also for the hauling of the additional facilities furnished in a postal car as compared with hauling mail as weight.

Until 1862 no attempt was made to distribute mail enroute on railways. The present general plan of paying for mails when formulated in 1873, fixed rates to be paid for mail as weight and also fixed additional rates effective when postal cars were furnished and hauled, whereby the Government could have the convenience of post-office features in the car and space for clerks to distribute the mails enroute. When mail is carried purely as weight, of course no extra post-office compensation is paid to the railways and as evidence that the postal car pay is not only not too great but is inadequate, we submit the following to show that it is less remunerative to the railroads to move mail in railway postal cars or in apartment cars, after considering the additional postal car pay, than it is to transport mail as weight in ordinary baggage cars:

The cost to a railroad of hauling a heavy empty car in a passenger train is approximately the same as hauling a lighter loaded car of equal gross weight. The latest standard 60-ft. steel baggage car used on the Union and Southern Pacific Lines has a dead weight of 41 tons, although the average baggage car of wooden construction weighs much less. The latest standard 60-ft. steel post-office car used on the same lines averages a dead weight of 56 tons, or 15 tons more than the baggage car. This difference in weight is due to the construction required according to the standards of the Post Office Department, including racks, pigeon holes, and various post-office features. It will be seen at once that 15 tons weight of mail could be hauled in the baggage car without exceeding the weight of the post-office car empty or without exceeding the cost to the railroad of hauling the latter car empty. The average weight of mail carried in post-office cars is only about 2½ tons, due to the large amount of space required for post-office features and by clerks to distribute mail enroute, while 20 to 30 tons of mail could readily be handled as weight but for the post-office features.

In other words, to handle mail in railway post-office cars and permit distribution enroute, the railroad is compelled to sacrifice all ideas of economy in transportation and abandon entirely the principal element of economy which would result from increasing the car load. Except for the post-office features and space requirements for clerks, instead of carrying an average of 2½ tons in a railway postal car, the railroads could easily carry an average of five times as much if mails were handled as weight, and could carry ten times as much without exceeding the carrying capacity of the car. The average weights carried in apartment cars are likewise limited because of the post-office features. For the latter the Government pays no additional compensation and for the full postal cars pays an additional compensation amounting to only 10% of the total compensation paid for handling the mails as weight, although as shown, the cost of handling mails in the traveling post-offices imposes an additional expense on the railroads many times as great as if the mail was handled as weight in sacks.

The amount paid to the railways for furnishing and hauling the traveling post-office cars is not only insufficient to reimburse the railroads for maintaining the cars and for interest and depreciation on their value, but is grossly inadequate to pay for the cost of hauling mail in this way as compared with hauling it as express or freight. It is for this reason that the railways have made the very reasonable request that compensation be allowed them for furnishing and hauling apartment cars for which they now receive nothing.

The Engineering News next compares the payments to the railways for hauling the "bags of mail" from one station to another with the wages of postmasters, clerks, letter carriers, etc. It is misleading to speak of hauling the "bags of mail" for, as has been explained, in addition to hauling "bags of mail" the railways furnish and haul post-office facilities so that these bags may be opened and their contents distributed by clerks while the railroad trains are running.

In handling the mails in this manner the railroads not only assist in rendering a great public service through advance distribution of mail enroute, but save the Government the expense of obtaining facilities for performing this post-office work elsewhere. The railways also transport the mail from railway stations to post-offices at the majority of their stations. In rendering this service and hauling the mails average distances of about 600 miles, the railroads certainly perform far greater service than the mere collection and distribution of mails at terminals, yet as shown by the preliminary report of Jan. 6, 1911, of the Committee on Railway Mail Pay, the railroads last year received nearly $20,000,000 less money for this service than the Government paid for the two items of city delivery and rural delivery. For the latter service, in carrying a comparatively small part of the mail short distances in the country, the Government is expending three-fourths as much money as is paid to the railroads for carrying the bulk of the mails very long distances.

The railroads received less money in 1910 than in 1907 yet they carried 22% more mail in 1910. On the other hand, the post-office department in 1910 increased its expenses over 1907 for rural and city delivery by $18,000,000; for salaries of postmasters and post-office clerks by $14,000,000, and the total expenses of the Post-Office Department were increased nearly $40,000,000.

Compare the 22% of the total postal revenue paid to the railroads for the great service rendered by them in carrying mails average distances of nearly 600 miles and for furnishing and hauling traveling post-offices, with the 50% to 55% of the revenue of express companies paid railroads for hauling express in bulk in ordinary baggage cars under conditions much less onerous to the railroads than in the case of mails.

The Engineering News advocates payments to the railroads on basis of actual operating expenses plus a fair percentage for profit. If correctly ascertained so that the mails bear their fair share with other traffic of all expenses such as maintenance, supervisory expenses, taxes and interest on roadbed, structures and equipment which the railroad must furnish for the conduct of any and all traffic, but which cannot be alloted to any particular business, such a basis would be regarded as entirely fair. This would follow the principles laid down by Hon. T. M. Cooley, First Chairman of the Interstate Commerce Commission, on June 15, 1887, as contained in the first annual report of the Interstate Commerce Commission, as follows:

> Every railroad ought, when it is practicable, to so arrange its tariffs that the burden upon freights shall be proportional on all portions of its line and with a view to revenue sufficient to meet all the items of current expense, including the cost of keeping up the road, buildings and equipment, and of returning a fair profit to owners.

Ignoring any of these items, however, would mean that passengers or shippers of freight would be obliged to bear the proportion of such expenses which the Government should pay for handling the mails—a conclusion not only unjust to the railroads but also to all the other patrons of the roads. In considering the justice of railway mail pay, the mail traffic as a whole must be taken into account, as rates paid by the Government to railroads are the same regardless of class. If it be found that some classes return more revenue to the railroads for the service furnished than others, it will be also found that the other classes are being handled by the railroads at greater loss because, as shown by the report of Jan. 6, 1911, of the Committee on Railway Mail Pay, from statistics collected, from a large part of the railroad mileage of the country, the following gross revenue is received by the railroads for handling passenger traffic per car-foot of space furnished, which was the unit specified by the Post Office Department:

Per car-foot of mail space	.3228 cts.
Per car-foot of express space	.3855 cts.
Per car-foot of passenger space	.4417 cts.

The average passenger train in the United States is composed of five cars each about 60 ft. long, or an average train length of 300 ft. A typical train of this length loaded entirely with mail would return the railroads a gross revenue of only 97 cts. per mile, if loaded with express, $1.16; if loaded with passengers, $1.33. For the average freight train run at freight train speeds the railroads receive, according to the last report of the Interstate Commerce Commission, $2.76, or three times as much as for an average typical passenger train composed only of cars handling mail.

Yours very truly,

The Committee on Railway Mail Pay.

24 Park Place, New York City, March 14, 1911.

[We give space with pleasure to the above statement as to the earnings of the railways from rental of postal cars, and accept the corrections to the figures originally published.

We may point out that the above statement further emphasizes the main point of the editorial to which it refers,—that a revision of the basis of railway mail pay is urgently needed. There is no reason in paying the railways rental for full postal cars and no rental at all for cars in which a half or a third of the space is used for postal purposes. It looks very much as if various readjustments of the railway mail pay had been made with the general idea that the railways were being paid extravagantly, so that they might therefore be compelled to furnish certain items gratis, such as furnishing free postal apartments in baggage cars and carrying the mails between the railway stations and the post offices.

So long as the present practice of basing railway mail pay on the weight of mail carried, there will be controversy as to whether the railways are being overpaid or underpaid. Take for example the comparison above, between the gross revenue to the railways per car-foot of mail-car space and per car-foot of passenger-car space. The excess of revenue for the passenger car space is certainly required by the railways because of the very much greater cost of handling passenger traffic than mail traffic in items aside from the cost of hauling the traffic over the road.

But the most important argument for a revision of railway mail pay to make it proportionate to cost of service is that the methods of handling mail may then be altered so that heavy mail matter, such as that which a parcels post would furnish and the publications constituting second-class mail matter can be moved over trunk line routes in heavily loaded cars at low cost.—Ed.]

The Threatened Disintegration of the Passaic Valley Sewerage District: A Rejoinder.

Sir: The recent editorial (Eng. News, Feb. 23, 1911), entitled "The Threatened Disintegration of the Passaic Valley Sewerage District," and Mr. Rudolph Hering's comments thereon (Eng. News, March 9, 1911) have been read by me with interest. I have had an intimate connection with the Passaic Valley project for several years and wish to add the following thoughts to those published in Engineering News under the dates cited.

The use of the word "disintegration" in the title is unhappy as there is absolutely no threatened *disintegration* of the *district*. The district was established by the Legislature in 1902, and its abolition has never been considered by the Legislature. The word disintegration, as used, is intended to apply, perhaps, to the particular trunk sewer project submitted by the Passaic Valley Sewerage Commissioners, in 1910, to the twenty municipalities comprising the district for their consideration. Yet even such use of the word disintegration seems not at all applicable because no union or harmonious action has ever been established between all of the communities.

The basic theme of the editorial is taxation and this is identical with the basic objection raised by a little group of wealthy communities, whose concerted action is apparently excited by two cities. The editorial came as a distinct surprise to me because of its partisan treatment of such a debatable subject as taxation and public assessments. It was expected that the Engineering News in its treatment of a subject upon which intelligent men can, after a careful study, reach with honesty and sincerity widely differing or opposing conclusions, would present in a fair manner the pros and cons with substantial justice to each of the opposing factions. The editorial presents but a partisan view of one phase of the many sided subject of taxation. And taxation has been debated for a thousand years. The editorial, however, with its partisanship makes an excellent campaign document and furnishes powder for those who seek the passage of a certain bill now pending before the New Jersey Legislature. Its use for the performance of such a political and partisan duty is clearly shown by its prompt publication and wide distribution in pamphlet form.

I am sure that the writers of the articles have given the matter of sewerage assessments careful and mature thought, and that they have reached the personal conclusions as set forth. They are aware, no doubt, that the many governing conditions surrounding and affecting the Passaic Valley project are peculiar, and also that no two trunk sewerage projects are necessarily alike or capable of consideration from the same viewpoint. Citizens may be easily found in each of the twenty communities of the district who sincerely and honestly concur with these personal conclusions of the editorial. Contrary minded there are hundreds and thousands of intelligent and honest citizens who believe with equal sincerity that the assessment of trunk sewer facilities in the particular case of the Passaic Valley project, at least, should be borne by the several communities in direct proportion to their taxable valuation. Such divergence of individual opinion has always existed since the invention of taxation.

The rich and also the powerful have always, as a class, endeavored to evade and have frequently succeeded in casting off a portion of the just burden of their wealth and power upon the poorer or the weaker. The rich and the powerful, taken as a whole, are only just beginning to realize that they are in any sense their brothers' keepers and that the good of all must overrule specific advantages to a favored class. If we go back, say as far as the instance cited in the book of Malachi, we find records of the rich and powerful individuals attempting to palm off for sacrifice and the payment of their tithes certain defective goods. Thus it has always been. When will it change?

Years ago certain of the rich and the childless used every means in their power to avoid the payment of public school taxes in proportion to their taxable valuation. Little is heard in objection to common school taxes to-day. Yet objecting individuals are still to be found. The writer has an acquaintance in mind, a

man of intelligence and ability, a skilled engineer and a resident of the rich town of Montclair, who stoutly maintains that so long as he remains childless he should not be taxed for the public schools. This man believes also that use and not wealth should bear the burden of sewage disposal facilities. An assessment based on use would favor his town. Others are known who believe that the cost of county and state institutions, court-houses, jails and insane asylums and the like would be more equably distributed if the basis of assessment was municipal use and not wealth.

The pollution of the Passaic River affects the whole of the lower drainage area as a *unit*. All of the communities lying within this natural drainage area are guilty, to a greater or lesser extent, for the existence of this unbearable nuisance. All of the twenty municipalities on the natural drainage area form parts or divisions of one large natural community. Each of these twenty parts has at least one common interest—the need of natural drainage into the Passaic River. The problem of the abolition of the existing nuisance is one that concerns the whole district, and the cost of the abatement must be borne by all—rich and poor alike—all must contribute, and the burden should bear proportionately upon all.

In considering the distribution of the assessments in this case, one fundamental error is sometimes made and this faulty premise runs through the editorial referred to—that of emphasizing the importance of the individual municipality. The problem is a problem of the whole—one of general welfare—and the political boundary between any two cities is of no more essential consequence, so far as the determination of assessment methods is concerned, than the political boundary between two city wards, or the boundary between two house lots, or the boundary between two individuals.

If recognition is taken of the municipal boundary lines and the assessments are apportioned in accordance to use, as the editorial urges, and as certain cities have prayed, then, with equal justice, the municipal allotment ought to be subdivided among the wards in accordance to sewer usage. If the measure of use is to prevail against relative wealth, then in like manner the effect should be extended down through all the gradation of units until each individual user pays in direct proportion to his use and the non-user should go free. But no! The champions of this method cease distributing the good or ill effects of their method after the first subdivision. This is notoriously unfair. If the measure of use is good for one town as against another then the same measure is equally good for the individual wards and the individual citizens.

An equable assessment on the principle of use carried to its last analysis is unfair and further is absolutely impossible. We have no practicable means of measuring the flow in a single house sewer connection nor of determining the percentage of use from an individual.

Centuries of human experience indicate that the most equable assessment of the cost of public necessities is in direct proportion to individual wealth as measured by taxable valuations. Everyone knows that even this approved method is not perfect and that it works, under peculiar conditions, individual hardships. For the small householder is obliged to pay towards expensive automobile roads even though he has no car and the millionaire bachelor must contribute toward the public school expenses even in the face of the fact that he has no personal need of them.

The Passaic Valley sewer assessments are allotted under the existing law, in direct proportion to wealth. The owner of a one thousand dollar estate pays exactly one-half the assessment levied on a two thousand dollar estate. Absolute equality is had in respect to wealth.

The cities of Orange, East Orange, Bloomfield, Glen Ridge and Montclair are situated on the southeasterly slope of Watchung Mt., an average distance of about four miles from the Passaic River, at an elevation ranging from 200 to 400 ft. above it. In this favored topographical situation they do not feel the sting that emanates from the intense pollution of the river. Certain of their citizens have even gone so far as to freely state that the intense and far-reaching nuisance arising from this foul river does not affect them personally in either comfort, health or in reduced property values. These five municipalities have complacently discharged all their crude sewage into the river for years and through this action they have done much to destroy the comfort, health and property value of their neighbors in the communities adjacent to the river.

Were it not for the fact that these communities are known throughout the country for the high standard of the intelligence and culture of their citizens, and their devotion to the best ideals of civic life, it might be suspected that the immunity from the nuisance created by their own filth, and the desire to escape, as far as possible, their proportionate burden entailed by their greater wealth, may have led them to confine their interests in the purifications of the Passaic to its theoretical rather than its practical aspects.

No action, or lack of action, on their part can remove them from under the ban put upon the whole sewerage district to cease polluting the river after the fixed date.

The five dissenting communities in ignoring the contract sanctioned by the remaining fifteen communities are exercising a right reserved for them by the Legislature. Each municipality within the district is free to adopt any proper and efficient mode of disposal of its sewage wastes that it desires.

Of the twenty municipalities comprising the district at least 15 have signified their approval of the entire project as presented by the commissioners, and are now urging prompt action in the execution of the work. Through courtesy these fifteen communities have waited for the remaining five to render a decision as to their intention of accepting or rejecting the project. The five communities which have thus far reserved decision are: Orange, East Orange, Bloomfield, Glen Ridge and Montclair. The last four have never made any attempt to gain a proper knowledge of the conditions surrounding the problem which the commissioners have attempted to solve, and have never made an investigation to determine whether or not the plans for the work as proposed would reasonably and adequately meet their needs for sewage disposal. East Orange, one of the richest communities within the district, has never paid a single cent towards the prosecution of the preliminary investigations, and the other four have paid but a trifling sum ($1,250 each). While these five communities have devoted little or no time, money and energy to further the project, which is designed for the good of all, they have, through certain officials and individuals, devoted much time and energy to the criticisms of many features of the general project, particularly those dealing with the method prescribed by the law, under which the commissioners are working, for the apportionment of the construction cost. The reason for this is obvious—they wish to reduce their individual or municipal assessment of the cost as apportioned by the said law and thus shirk a portion of the burden on their wealth.

Mr. Hering's criticism of the stipulations of the agreement entered into with the United States Government regarding the treatment of sewage and the methods of discharge into New York Bay reads strange in the light of the fact that the stipulations of this very agreement were drawn up by Messrs. Hering & Fuller in consultation with the other consulting engineers of the commissioners. These stipulations were subsequently recommended by the said engineers to the New Jersey State officials and to the Passaic Valley Sewerage Commissioners for adoption. The signature and the approval of said stipulations by Messrs. Hering & Fuller are attached to the document in question. Furthermore, Messrs. Hering & Fuller and other engineers spent over a year securing data at home and abroad, and in consultation with the United States Engineers, before the items of the said agreement were formally and finally settled. For this service the state of New Jersey paid Mr. Hering and his associates several thousand dollars.

Mr. Hering should also know that no community in the district can secure practical disposal of its sewage by local action, except at a cost considerably above the cost of the trunk sewer, as apportioned by the present law. If it were possible for this to be done, no sentimental regard for the maintenance of the sewerage district as a whole would stand in the way of the communities now criticising the plans, in adopting individual action.

The only formal plan thus far proposed for these five criticising communities complacently suggests that the nuisance arising from prospective disposal works be placed within the territory of another community, with childlike faith that this community, having arranged to dispose of its own filth through the trunk sewer, would gladly receive a new and perpetual nuisance from the wealthy hillside towns.

Precedents in Massachusetts and other states have been cited as to conditions of payment, without the consideration that these states are able to lend their credit in the financing of public enterprises of this character, that these states may assume the burden of the debt and issue state bonds for the raising of necessary funds, and that they are able also to enact special laws for the promotion of such enterprises. Such procedures under the New Jersey Constitution are absolutely prohibited.

The distribution of the burdens in direct proportion to the value of the taxable valuations affected has proven to work substantial justice. It is well known that no law or governmental impost has ever yet been formulated which could, in every case, stand a mathematical test of bearing equally, for all time, on all persons and property, and no group of experts has ever yet been found who could agree as to where and to what extent a cure could be applied without creating new hardships elsewhere. It is easy to formulate means to disturb the equilibrium. It is easy for a man with a hundred thousand dollar property to discover means to cast a part of his burden of his wealth on the tenement dweller. Such a thing is not hard. Anybody can do it. It is easier to tear down than to build up. No assessment law has ever been made that works perfect justice. Who can devise one? Mr. Hering joins with the editorial opinion that this method is strikingly unjust to certain of the communities. Mr. Hering's favorable reputation as a sanitary engineer is known throughout the world, but I have never heard of him as being considered an expert in either constitutional law or public policy—subjects which have controlling influence on the methods of taxation under consideration.

The payment of the construction costs in the Passaic Valley case, as now prescribed by the law, is to be made in direct proportion to the taxable wealth. A community having one-tenth the total wealth of the district pays one-tenth of the construction costs. This principle and method is the result of a remarkably full discussion in all the courts of New Jersey, where other methods have been proposed and rejected. The method has also been exhaustively discussed by several legislatures. It has also the merit of following all the precedents established and sustained in the state of New Jersey for the payment of cost of public works, necessities and improvements covering and affecting a large extent of territory, such as county roads and bridges, court-houses, jails, county and municipal institutions, water-supply, trunk sewers, schoolhouses—namely, an apportionment based upon assessed value of ratables of the territory affected. The personnel of the owner, or the use to be made of the thing paid for, is not considered. This method follows the spirit of the state constitution—that property shall be assessed by uniform rules and at true values.

All attempts to adjust, modify, or shift these burdens under the plea of more equitable adjustment may usually be traced to the desire to shift the load of a favored class upon the less fortunate majority, and our court records are full of decisions nullifying such laws, when tested, as being unconstitutional, or class legislation.

Mr. Hering criticizes the law as being unsatisfactory from an engineering point of view. It is an old grievance among engineers that laws authorizing engineering works are often unsatisfactory when they prescribe technical features. On rare occasions an engineer has the drawing of an act. The usual sequence is the declaration, by the courts, of its illegality.

Yours truly,

Edlow W. Harrison.

15 Exchange Pl., Jersey City, N. J., March 21, 1911.

Sir: You have sent me a letter written to you by my friend, Mr. Edlow W. Harrison, Chief Engineer of the Passaic Valley Sewerage Commissioners, in a part of which he takes exception to some of the statements I made in a letter to you dated March 1, 1911. I should very much prefer to remain quiet, but this great public work, so urgently needed, is a matter concerning which people should be enlightened as much as possible to clearly understand some of the intricacies of the problem which vitally concerns them. They should do this before they embark and not be left to learn of the results after they are out at sea. There are but a few statements to which I care to reply.

Mr. Harrison says that my criticism of the stipulations of the agreement entered into with the U. S. Government as to the treatment of sewage before it is discharged into New York Bay "reads strange in the light of the fact that the stipulations of the very agreement were drawn up by Messrs. Hering & Fuller * * *."

I thought Mr. Harrison knew, as others do know, that I reluctantly agreed to the compromise, believing that an open trial with all the facts brought out would have clearly shown that the contention of the Passaic Valley Sewerage Commissioners, to the virtual effect that only screening and grit chambers are needed, was right. A compromise was justifiable and secured our cooperation only for the sake of saving time in beginning construction, with the personal belief that before the portion of the works affected by the compromise would be actually built, the real problem and its best solution would become quite apparent and that a revision accordingly would then no doubt be made.

We, therefore, began the letter to the Commissioners, suggesting the stipulation, by the words: "*As requested by you* we have prepared and present herewith a plan and description of settling tanks, which * * * it is feasible * * * to install * * *." These basins, other than for the purpose of holding back grit, were not in the original plan and have always been considered by me, particularly the first basins proposed, as not only adding to the cost, but inviting objectionable conditions which would be obviated by their absence.

Therefore, we say on the second page of the letter referred to by Mr. Harrison, and which contained the stipulations:

> We are firmly of the opinion that these tanks, if required, are of a greater capacity than necessary either to prevent a deposition of suspended matters of the Passaic Valley sewage upon the bottom of New York Bay or to prevent the appearances of suspended matters of the sewage in the surface waters of the bay; and as to the size of these tanks, we have yielded in our opinions to the desires which have been stated to your Commission to have somewhat more of the putrescible organic matter removed from the Passaic Valley sewage, and demanding local treatment, before it enters New York Bay, than would be accomplished with the settling tanks previously recommended by us.

We succeeded in reducing the retention period of 8 hours, as originally proposed by the objectors, to 1½ hours of storage. This made it possible to prevent a thorough septicization or fouling of the sewage to be

discharged into New York Bay, with all its consequences, and facilitated the possible adoption of an inodorous sludge-disposal plant. But while that was a satisfactory compromise, the necessity for this additional expenditure did not then and does not now exist, in my opinion.

The second statement which needs a reply, is this:

> Mr. Hering should also know that no community in the district can secure practical disposal of its sewage by local action, except at a cost considerably above the cost of the trunk sewer as apportioned by the present law.

In the light of the present law, my knowledge is quite to the contrary.

Mr. Harrison further says

> that the only formal plan proposed for these five criticizing communities complacently suggests that the nuisance arising from prospective disposal works be placed within the territory of another community, with childlike faith that this community * * * would gladly receive a new and perpetual nuisance from the wealthy hillside territory.

Mr. Harrison probably refers to the plan of Mr. Harrison P. Eddy, prepared at the request, I believe, of East Orange, but the text of Mr. Eddy's report nowhere even intimates that he advises its adoption as against the Passaic Valley Commissioners' project. But it is strange that Mr. Harrison to-day, and as an engineer claiming knowledge concerning sewage-disposal works, should say that Mr. Eddy's plan or any other up-to-date sewage-disposal works, would make such a nuisance as he intimates. To the credit of the profession let this be corrected and let no older works be quoted as representing what works now built by competent parties will do.

The chief bone of contention at the present time is that part of the law which apportions the cost. Mr. Harrison wants the wealthier people to pay more than the poorer people for having their sewage removed. He, therefore, is directly opposed to another method which compels in many cities the poorer people to pay the highest meter price for water, while the wealthier and larger users, including manufacturers, pay less per gallon, although it costs practically as much to supply one as it does the other.

My own position for many years has been to advocate the apportionment of the cost of water and sewage works as nearly as practicable according to the quantity used or delivered, as is paid for other goods, modified somewhat by the conditions under which the water is delivered and the sewage is collected and disposed of. I grant that a perfectly equitable apportionment is impracticable, but I deny that it cannot be done more equitably than by the law in question. If the most equitable method is not constitutional in New Jersey, this does not oblige the engineer to change his ideas of justice. I cannot see why one part of the district should pay the expense of the housekeeping in another part, unless both are one family and the contribution be considered a voluntary assistance to the less-favored part of the district. As a resident of the former, I should personally be greatly pleased to assist in this way, but I cannot consider it just so long as more equitable means are possible.

Mr. Harrison's last paragraph must be heartily endorsed by every engineer and citizen, and it indicates how large amounts of money have been lost to communities. If the usual sequence is, "illegality," then the fault is not engineering, but legal. If the engineer tries to fix or interpret a law of the land, he is in the same predicament as the lawyer who tries to fix or interpret the practice of engineering or of science. Each profession has its legitimate sphere of action and usefulness; one is not a bit better than the other, one cannot do without the other, and both are absolutely necessary in such cases as the present one. But the duty of the engineer, figuratively speaking, is to draw the picture and the duty of the lawyer is to frame it, so that it is in a form and in condition to be useful, presentable, attractive and [illegible]nt. The reverse, or any mixing up, is usually more or less disastrous.

Yours truly,

Rudolph Hering.

170 Broadway, New York City, March 30, 1911.

[Mr. Hering has spoken for himself in the letter which precedes. As for ourselves, what we wrote on the apportionment of cost of joint sewerage systems was in accordance with views long held and often expressed in these columns on the raising of funds to pay for various classes of public improvements.

The rifle of general taxation, that every one should pay according to his ability, has never been extended to apply to every kind of governmental service. Instead, the rule of benefit is widely used, either as a yearly charge for services rendered, or as a lump-sum assessment on a front-foot or other basis.

So far as sewerage is concerned, we venture the guess that for every dollar raised by general taxation to pay the first cost of sewerage systems at least two have been raised by assessment for benefits. In the case of at least one of the five communities which Mr. Harrison criticises in his letter, individual property owners were assessed on the front-foot basis for (1) laterals, (2) local trunk sewers, (3) a joint outlet to the Passaic River.

Coming now to the proposed Passaic Valley sewerage scheme, let us note first of all that the obligation resting on each of the municipalities is to stop *its own* pollution of the river. Mr. Harrison urges, in effect, that the obligation does not extend this far in the case of the poorer, but goes farther in the case of the richer communities. At the same time he distinctly states that each community has a right to choose means of stopping the pollution through independent action instead of going in to the district scheme. Is this consistent?

So far as we know, all joint sewerage schemes, when entered into through freedom of contract instead of by legislative compulsion, have been financed on the basis of capacity allotted to each municipality. This applies to first cost. Maintenance charges have been apportioned on yearly volume of sewage. The Orange-Montclair-Bloomfield outlet sewer was paid for on this plan, and so, if we mistake not, was the East Orange-Newark joint outlet. So, too, was the large union outlet sewer built some years ago by eleven municipalities in Essex and Union counties. Neither courts nor constitution stopped these communities from apportioning cost of joint sewers on the capacity basis.

Equally fallacious is the argument that the capacity basis is impracticable, for (1) as has just been shown, it has been carried out both in and adjacent to the very district in question; (2) it is thoroughly rational and equitable as a matter of public policy, and (3) it is simple as an engineering task. The first thing an engineer confronted with designing and estimating the cost of a joint sewerage system does is to determine the volume to be provided for each municipality. What difficulty, then, in apportioning the first cost on the capacity basis? The case is far different as regards roads and various other public improvements, but the first cost of street openings, of original paving and sometimes of repairs are commonly assessed on the property benefited. It is true that the cost of our common schools is firmly based on general taxation, thanks to principles which underlie our whole national history, but which have nothing whatever to do with sewerage systems.

We think Mr. Harrison goes too far in questioning the competency of Mr. Hering in particular and engineers in general to discuss questions of public policy and even to take a hand in framing statutes and contracts. (And by the way, if not, how does Mr. Harrison, himself an engineer, justify his own long discussion of questions of public policy?) We are in great need of engineering knowledge and ordinary common-sense in connection with both. As for the particular matter in question, if ever lawyers and legislators together made a nasty muddle then they have done it repeatedly in the fifteen years' history of the Passaic Valley Sewerage District. The engineers cannot be held blameworthy, we are sure, for the unconstitutionality of the statute of 1903, which not only violated the principle of representative government, as does the present statute, but also sought to impose heavy burdens of taxation on the several communities without leave to say yea or nay.

As for the bill now before the New Jersey legislature, which attempts to remedy the injustice of the present valuation basis of meeting cost by still requiring the several communities to issue bonds on this basis, but permitting them to contribute to interest and sinking fund charges in accordance with actual use only, we consider it to be a roundabout and awkward method of solving a very simple problem—a method which may be a credit to lawyers but which, or the possible necessity of which, would be a disgrace to engineers.

Mr. Harrison confines his criticisms almost wholly to one of the four main heads of our editorial. The general conclusion of our whole discussion was that the changed conditions during the past ten to fifteen years, combined with the unfair method of distributing first cost, demand a careful restudy of the Passaic Valley sewerage problem, at least if it be desired that the threatened disintegration of the district be averted—or if Mr. Harrison prefers, that the district become united, which he himself says it has never yet been.

Were the problem to be restudied in all its phases, in the light of present ideas of water pollution and the present theory and practice of sewage disposal—all of which have changed materially in fifteen years—many of the obstacles Mr. Harrison thinks he sees in the way of the capacity or usage basis of distributing cost might disappear, and several million dollars of outlay be saved, or at least postponed. Perhaps the trunk sewer project itself would also disappear and in place of it there might emerge plans for a number of sewage disposal plants, each to serve one or more communities. Or, it is barely possible, as Mr. Hering suggests it is eminently desirable, that the United States Government would consent to modifications in the compromise plans which would restore a large part of the advantages of disposal into New York Bay.

Whatever might or might not be the result of a restudy, it should not be forgotten that *the one great argument for a trunk sewer* was at the outset, and ever will be, the elimination or material reduction of the necessity for purifying the sewage of the district. A *great disadvantage of the trunk sewer* is that it requires heavy present outlays to provide capacity for communities as yet but little developed. One of these, as we pointed out in our editorial on Feb. 23, has virtually no sewers at present. Such sewage as it will be likely to have for disposal for years to come might be discharged into the Passaic with harm to nobody, the sewage of the larger municipalities having been removed. The present trunk sewer plan, with the valuation basis of meeting its cost, compels built-up communities to pay a large part of the first cost of the capacity provided to meet the future needs of this and other undeveloped communities. This is one of the chief reasons why the valuation basis seems imperative.

Through many years we were firm believers and constant supporters of the trunk-sewer plan, although we always considered the valuation basis of meeting cost unjust. We have strongly upheld the right of the New Jersey communities to utilize the waters of New York Bay for disposal by dilution, against the arguments of the Metropolitan Sewerage Commissioners of New York and others—and Mr. Harrison never accused us of partisanship on that score, even if we did confine our arguments to what we believed to be the strongest, as well as the right side of the case. We are still inclined to the trunk-sewer plan, rationally executed and financed, and we yield not an inch in our stand on the discharge of sewage into New York Bay. But time flies and with it there is progress in nearly everything except cleaning up the Passaic River and guaranteeing justice to the communities that enter the district. Lawyers and legislators and laymen have had their chance for fifteen years. Engineers have been kept at arm's length, and when employed have done their work with meager funds at their command, as Mr. Harrison, Mr. Hering and every other engineer connected with the project knows to his sorrow. Although they publish no stated financial reports it is understood that the Commissioners owe money on oft-renewed notes, besides being in debt to engineers, to lawyers and to other employees, while some of the Commissioners have foregone or agreed to a postponement of their salaries.

As Mr. Harrison says, the district has never been united. Can he or the Commissioners justly complain if engineers and engineering journals (for this journal is not alone) criticise some of the communities, complain of injustice and propose remedial legislation and, as an alternative, independent works?—Ed.]

Progress on the Panama Canal Construction.

The discerning visitor to the Panama Canal work cannot fail to be impressed by the speed with which the construction is being pushed. As one walks through Culebra cut, and watches the huge steam shovels eating away the banks, the rows of well and tripod drills hammering away at the rock and the steady procession of heavily loaded trains steaming away to the dumps while empty ones rush eagerly back for another load,—as one watches this busy panorama, he might easily conclude that some hustling contractor was engaged on this job with an engineer standing over him dinning into his ears that time was the essence of his contract; that a big penalty awaited him for every day of deliquency after the contract date for completion and a big premium for turning over the completed work ahead of the day set.

The same impression is made as one watches the work on the lock construction, where the hive of industry is even more concentrated. One may stand on the porch of the engineering headquarters at Gatun to-day and watch the automatic electric cars, which bring the charge of cement and sand and stone to the concrete mixers file past in endless procession; the busy little electric trains carrying the full buckets of mixed concrete to the cableways and bringing back the empties; the great cableways hoisting the heavy buckets of mixed concrete high aloft as quickly as if they were a mere feather weight, then swiftly running them out over the locks and lowering them where they are to be dumped. At the same time dump-car trains of concrete from another mixer plant are being rushed by puffing locomotives to and from the work on the lower lock floor. Longer trains of larger dump cars are bring back-filling to be placed behind the lock walls. Other trains still are bringing spoil from Culebra and dumping it on the sides of the Gatun dam. In the distance the smoke is rising from great dredges which are steadily pumping sand and clay into the heart of the dam and from others which are digging away on the sea level section which is to extend from the lowest Gatun locks out through the swamps to Limon Bay and the Caribbean Sea.

Exactly the same impression is made if one goes over to the Pacific end of the Culebra cut and watches the lock construction work at Pedro Miguel or Miraflores or the excavation going on in the sea level section between Miraflores and the Pacific wharves at Balboa. Thus along the whole length of the canal works, from the dump where the breakwater leading to Naos Island in Panama Bay on the Pacific end is being built up, to the steady procession of tugs and barges bringing crushed rock from the Porto Bello quarries to Gatun, at the Atlantic end, one sees work progressing at rapid pace, during every hour of the day.

There is sound reason for this speed. If the canal were being built by private enterprise, for profit, the interest on the bonds issued year by year to pay for the work as it progressed would constitute a heavy drain on the company's treasury; and every effort would be put forth to get the work completed and in operation at the earliest possible day so that it might be earning money to meet these fixed charges. The same principle applies although the work is being paid for from the United States treasury.

But there is even a stronger reason why it is sound economy to push the work at high speed, even if the cost per unit were thereby increased. That reason is the heavy cost of carrying on the sanitation and civil government of the Zone while the work of construction continues. The sooner the job is finished, the sooner can this expense be cut off or rather reduced to the amount necessary for whatever establishment we permanently maintain in the canal zone.

The success of Col. Goethals and his associates in the conduct of the work is nowhere more evident than in the degree with which they have inspired the whole personnel with the spirit of hustling and striving to beat the record. The cubic yards daily output of each steam shovel or each dredge or each concrete laying plant is watched as eagerly as the returns from a baseball game, and the final result is a most gratifying and remarkable rate of progress on the entire work.

So far as the excavation is concerned, the progress made up to Feb. 1, 1911, is summarized in the diagrams which are published herewith, and which will well repay study.

The feature of greatest public interest in connection with the canal work from the beginning has been the great Culebra Cut. The profile shows at a glance how great an amount of material has been removed from this section compared with what still remains. It also makes clear how trifling was the total excavation necessary in the Gatun Lake section from Gatun locks to the beginning of the Culebra cut at Bas Obispo, thanks to the adoption of the lock plan of construction instead of the sea level plan. This is due of course to the fact that this section will be flooded by Gatun Lake and the only work necessary has been the excavation of projecting ridges and peninsulas, quite shallow for the most part, in order to give the required depth of water in the canal channel. The excavation in the Gatun Lake section will be all finished during the present month.

In the whole Central Division the material remaining to be excavated on Feb. 1, 1911, was 27,720,000 cu. yds. February and March have been dry-season months of heavy output. The latter month is expected to show the largest volume of excavation in Culebra cut of any month during the entire period of construction. The amount remaining to be excavated in Culebra cut on April 1, therefore, will not exceed, probably, about 24,500,000 cu. yds.

Compare now this amount with the record of excavation in the Central Division for the fiscal year ending July 1, 1910, which was 17,832,000 cu. yds., and it is seen that if this rate were maintained till completion, the Culebra cut would be all dug in about 16 months more, or by August 1, 1912.

Of course no such rate of progress is possible or is expected, for as the cut deepens and narrows, fewer shovels can be worked. In fact a considerable percentage of the shovels would already have been thrown out of service had it not been for the additional material brought in by the slides which have made necessary more work in the upper part of the cut.

However, allowing for the reduced rate of output which may be expected from now onward, it is evident that Jan. 1, 1913 will see the Culebra cut—which seemed such a veritable mountain, no more than five years ago—if not entirely completed, so nearly done that there will be nothing but a small amount of clearing up left.

One qualification should be made to this. The quantity remaining to be excavated on Feb. 1, is based on a certain estimate of the amount of material which will have to be removed from the slides which are moving into the canal prism. It is possible that this estimate may have to be materially increased as further material on the banks breaks away and slides into the cut. These slides, however, need not necessarily delay the opening of the canal. The filling of the cut with the water of Gatun Lake will probably be of material benefit in putting pressure upon the sides and bottom of the prism to hold the banks in place. Further, if more earth or broken rock from the banks slides into the cut

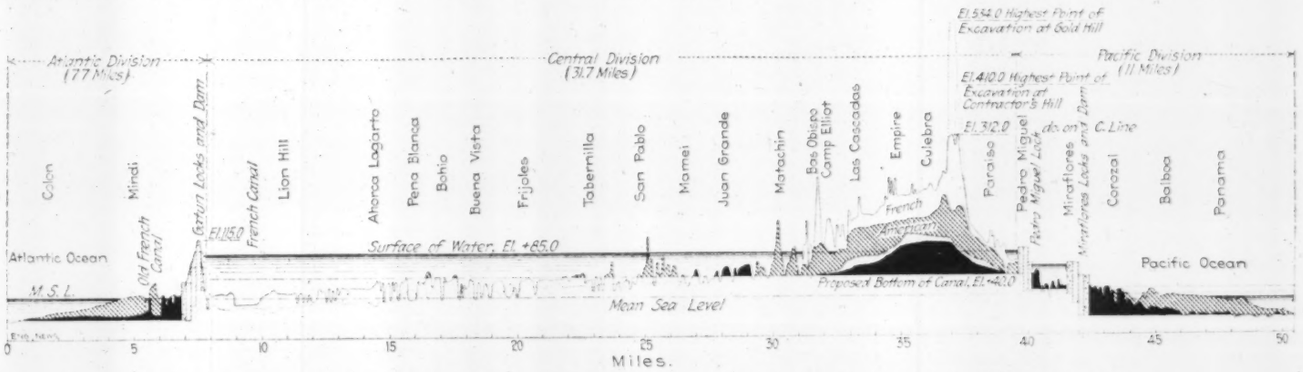


FIG. 1. PROFILE SHOWING PROGRESS OF WORK ON THE PANAMA CANAL EXCAVATION TO FEB. 1, 1911.

Col. Geo. W. Goethals, Chairman and Chief Engineer; Lieut. Col. H. F. Hodges, Assistant Chief Engineer.

ATLANTIC DIVISION, 7.7 MILES.

Lieut.-Col. Wm. L. Sibert, Division Engineer.
Major Chester Harding, Asst. Division Engr.
Major Edgar Jadwin, Resident Engineer.
Major J. P. Jervey, Resident Engineer.

Estimate of cu. yds. to complete canal	43,357,345
Cu. yds. excavated to July 1, 1910	25,737,810
Cu. yds. remaining July 1, 1910	17,619,535
Cu. yds. excavated to Feb. 1, 1911	29,482,546
Cu. yds. remaining Feb. 1, 1911	13,874,799

CENTRAL DIVISION, 31.7 MILES.

Lieut.-Col. D. D. Gaillard, Division Engineer.
A. S. Zinn, Resident Engineer.

Estimate of cu. yds. to complete canal	97,125,018
Cu. yds. Excavated to July 1, 1910	58,815,343
Cu. yds. remaining July 1, 1910	38,309,475
Cu. yds. excavated to Feb. 1, 1911	69,404,654
Cu. yds. remaining Feb. 1, 1911	27,720,384

ENTIRE CANAL EXCAVATION.

Estimate of cu. yds. to complete canal	182,537,766
Cu. yds. excavated to July 1, 1910	110,763,623
Cu. yds. remaining July 1, 1910	71,774,143
Cu. yds. excavated to Feb. 1, 1911	128,221,559
Cu. yds. remaining Feb. 1, 1911	54,316,207

PACIFIC DIVISION, 11 MILES.

S. B. Williamson Division Engineer.
John M. G. Watt, Asst. Div. Engr.
W. G. Comber, Resident Engineer.
W. B. Corse, Resident Engineer.

Estimate of cu. yds. to complete canal	42,055,403
Cu. yds. excavated to July 1, 1910	26,210,270
Cu. yds. remaining July 1, 1910	15,845,133
Cu. yds. excavated to Feb. 1, 1911	29,334,379
Cu. yds. remaining Feb. 1, 1911	12,721,024

COST OF EXCAVATION WORK ON CENTRAL DIVISION, PANAMA CANAL, MAY 1.

Date.	Average No. Shovels working.	Days.	Average output per shovel. Per day.	Per month.	Work excavation accomplished, cubic yards. Earth.	Rock.	Total.	Cost per cubic yard, Direct charges. Super-vision.	Shovel expense.	D. & B. mach. excav.	Trans.	Dumps.	Tracks.	Hand excav.	D. & B. hand excav.	Drain-age and sump.	Clear-ing site.	Gen'l sur-veys.
To June 30, 1907..	14.20	26	607.7	15,799	3,419,949	4,656,378	8,076,327	.0859	.1928	.2564	.4434	.2282	.1233	.....	.....	.....	.0003	.....
July, 1907.....	43.38	26	683.2	17,740	232,520	538,050	770,570	.0209	.1319	.1845	.2777	.1808	.1099	.....	.....	.....	.....	.....
August, 1907.....	39.85	27	734.0	19,818	302,513	487,253	789,766	.0123	.1575	.1520	.2282	.2004	.1588	.....	.....	.....	.....	.....
September, 1907...	39.42	24	819.2	19,661	245,382	529,632	775,014	.0213	.1432	.1468	.2493	.1948	.1683	.....	.....	.....	.0035	.0019
October, 1907.....	39.85	27	709.4	21,585	279,225	580,901	860,126	.0238	.1453	.1433	.2972	.1575	.1727	.....	.....	.....	.0017	.0016
November, 1907....	44.88	24	773.3	18,562	264,382	570,284	834,676	.0262	.1543	.1658	.2512	.1644	.1725	.....	.....	.....	.0016	.0014
December, 1907....	48.84	25	922.3	23,057	491,690	632,447	1,124,137	.0187	.1040	.1408	.1969	.1243	.1432	.....	.....	.....	.0004	.0021
January, 1908.....	51.53	26	1039.5	27,031	546,723	849,746	1,396,469	.0169	.0736	.1480	.1576	.1148	.1148	.....	.....	.....	.....	.0012
February, 1908....	54.00	24	1112.1	26,690	631,954	816,456	1,448,410	.0136	.1108	.1218	.1473	.1019	.1071	.....	.....	.....	.....	.0007
March, 1908.....	53.66	26	1159.4	30,146	779,256	835,862	1,615,118	.0115	.0807	.1173	.1334	.1002	.0888	.....	.....	.....	.....	.0006
April, 1908.....	53.04	25	1191.1	29,780	714,575	857,482	1,572,057	.0132	.0903	.1294	.1371	.1118	.0933	.....	.....	.....	.....	.0008
May, 1908.....	53.24	25	905.7	22,618	449,720	747,022	1,196,742	.0148	.1365	.1702	.1805	.1399	.1029	.....	.....	.....	.....	.....
June, 1908.....	55.15	26	1011.2	26,294	439,572	1,016,605	1,456,177	.0132	.1157	.1237	.1456	.1287	.0845	.....	.....	.....	.....	.....
Year 1907-8.....	48.07	25	920.2	23,582	423,239	730,053	13,839,262	.0163	.1151	.1414	.1855	.1339	.1190	.....	.....	.....	.0005	.0009
July, 1908.....	52.57	26	1073.2	27,902	471,738	995,344	1,467,082	.0151	.1093	.1084	.1522	.1077	.0831	.....	.....	.....	.....	.....
August, 1908.....	52.58	26	1119.6	29,300	530,153	1,010,457	1,540,610	.0109	.1180	.1266	.1677	.1031	.0904	.....	.....	.....	.....	.....
September, 1908...	49.68	25	1180.2	29,585	414,624	1,055,184	1,469,808	.0120	.1190	.1283	.1793	.0968	.0986	.....	.....	.....	.....	.0005
October, 1908.....	49.55	27	1185.3	32,228	555,603	1,029,349	1,585,012	.0113	.1095	.1122	.1418	.0978	.0851	.....	.....	.....	.....	.0002
November, 1908....	50.91	23	1154.8	26,693	425,052	933,914	1,358,966	.0119	.1128	.1124	.1626	.0962	.0854	.....	.....	.....	.0002	.0001
December, 1908....	50.73	26	1210.5	31,474	523,181	1,070,813	1,593,994	.0117	.1072	.1248	.1482	.1016	.0866	.....	.....	.....	.0001	.0007
January, 1909.....	51.80	25	1183.0	29,575	506,866	1,032,782	1,539,648	.0132	.0982	.1214	.1447	.0941	.0921	.1274	.....	.....	.0037	.0002
February, 1909....	56.05	23	1260.4	29,342	606,991	1,037,695	1,644,686	.0107	.0949	.1072	.1338	.0763	.0759	.4233	.....	.....	.0029	.0001
March, 1909.....	56.93	27	1327.2	35,835	796,785	1,257,303	2,054,088	.0088	.0804	.1083	.1077	.0722	.0693	.4902	.....	.....	.0118	.0001
April, 1909.....	55.40	25	1283.7	32,120	710,765	1,072,001	1,782,766	.0101	.0811	.0983	.1226	.0523	.0713	.4960	.....	.....	.0172	.0001
May, 1909.....	54.60	25	1182.9	29,507	502,397	1,010,736	1,513,133	.0109	.0997	.1114	.1449	.1268	.0848	.3601	.....	.....	.0166	.....
June, 1909.....	45.65	26	1242.9	32,315	400,682	1,117,352	1,518,034	.0117	.0967	.1249	.1476	.0877	.0903	.3216	.....	.....	.....	.....
Year 1908-9.....	52.20	25	1200.3	30,480	537,075	1,056,911	19,067,777	.0113	.1000	.1149	.1452	.0911	.0837	.3935	.....	.....	.0048	.0001
July, 1909.....	45.08	26	1206.9	31,379	369,332	1,065,393	1,434,725	.0144	.1018	.1390	.1698	.0832	.1055	.1318	.1908	.0085	.....	.0001
August, 1909.....	46.75	26	1132.9	29,454	361,558	1,043,355	1,404,913	.0142	.0997	.1360	.1668	.0787	.0974	.1222	.1390	.0027	.0001	.0002
September, 1909...	46.60	25	1248.3	31,208	364,147	1,107,649	1,471,796	.0125	.0875	.1446	.1445	.0680	.0886	.2089	.2388	.0049	.0001	.0003
October, 1909.....	47.23	26	1230.1	32,079	328,013	1,196,297	1,524,310	.0117	.0792	.1245	.1393	.0639	.1014	.2083	.2139	.0042	.0002	.....
November, 1909....	41.75	24	1161.3	27,875	196,165	968,246	1,164,411	.0156	.0988	.1340	.1935	.0756	.0831	.2670	.1582	.0039	.0001	.....
December, 1909....	43.15	26	1114.6	28,982	251,978	1,005,088	1,257,066	.0129	.1039	.1471	.1713	.0741	.0861	.2650	.....	.0040	.0001	.....
January, 1910.....	46.68	25	1252.3	31,307	366,919	1,132,576	1,499,495	.0397	.1045	.1018	.1344	.0706	.1238	.2228	.....	.0027	.0592	.0004
February, 1910....	51.35	23	1272.8	29,274	412,346	1,133,136	1,545,482	.0128	.0805	.0883	.1418	.0594	.0821	.2282	.....	.0026	.....	.0005
March, 1910.....	53.92	26	1388.0	36,090	711,908	1,282,606	1,994,574	.0105	.0666	.0791	.1209	.0488	.0763	.2947	.0107	.0023	.0006	.0005
April, 1910.....	50.04	26	1295.2	33,674	551,070	1,166,552	1,717,622	.0115	.0754	.1177	.1386	.0574	.1080	4.95	.0214	.0048	.0012	.0005
May, 1910.....	44.80	25	1263.8	31,596	387,630	960,623	1,348,253	.0136	.0962	.1079	.1738	.0734	.1366	.7306	.....	.0141	.0003	.0004
June, 1910.....	45.15	26	1229.2	31,962	295,728	1,173,802	1,469,530	.0142	.0871	.1273	.1393	.0667	.1064	.....	.....	.0082	.0012	.0005
Year 1909-10.....	46.87	25	1233.0	31,290	383,066	1,102,949	17,832,177	.0150	.0888	.1190	.1522	.0657	.1001	.2139	.1363	.0052	.0046	.0003
July, 1910.....	45.84	25	1231.4	30,786	288,913	1,031,003	1,319,916	.0149	.0958	.1380	.1805	.0689	.1152	.....	.....	.0067	.0001	.0003
August, 1910.....	44.63	27	1330.1	30,224	434,497	1,177,621	1,612,118	.0112	.0738	.0985	.1258	.0645	.1143	.....	.....	.0025	.....	.0002
September, 1910...	46.92	25	1340.2	33,505	459,473	1,114,765	1,574,238	.0129	.0767	.0945	.1386	.0619	.0995	.....	.....	.0008	.....	.0002
October, 1910.....	47.50	26	1294.2	33,649	515,045	1,076,678	1,591,723	.0127	.0781	.0884	.1469	.0644	.1150	.....	.....	.0008	.....	.0004
November, 1910....	49.13	24	1225.2	29,403	417,359	1,653,077	1,470,436	.0149	.0624	.0927	.1598	.0565	.1216	.....	.....	.0017	.....	.0002
December, 1910....	45.58	26	1170.3	30,424	399,883	1,008,998	1,408,881	.0134	.0595	.1090	.1754	.0546	.1442	.....	.....	.0029	.....	.0003
January, 1911.....	47.68	25	1330.0	32,251	453,419	1,158,360	1,611,779	.0116	.0678	.1027	.1375	.0497	.1205	.....	.....	.0062	.....	.0002

*Drilling and blasting.

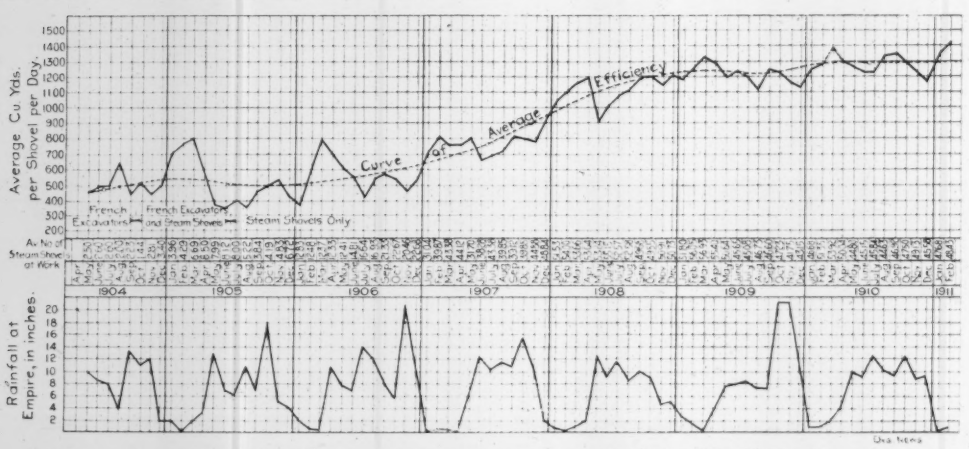


FIG. 2. DIAGRAM SHOWING EFFICIENCY OF STEAM SHOVELS WORKED ON CENTRAL DIVISION OF THE PANAMA CANAL.

after it is filled with water, it can be removed with dredges at a cost probably of not over 10 cts. per cubic yard while the cost of removal with steam shovels and trains at present is in excess of 50 cts. per cubic yard. It is not improbable that considerable dredging to remove sliding material will be necessary in the cut for a dozen years or more after the canal is opened.

The excavations on the sea-level sections, from the Gatun locks to deep water in Colon bay and on the Pacific end from the Miraflores locks to deep water in Panama bay, is making corresponding progress with that on Culebra cut. The comparison between the quantity remaining to be excavated on Feb. 1 and the average monthly rate of progress in the year ending July 1, 1910, is as follows:

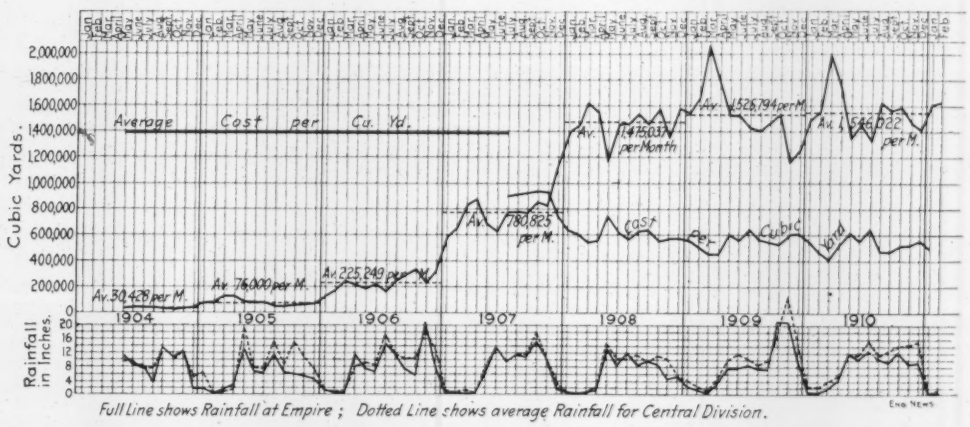
	Atlantic Division.	Pacific Division.
Quantity to be excavated, Feb. 1, 1911, cu. yds.	17,619,535	12,721,024
Ave. excavation per mo., last fiscal year	523,511	645,318

From this showing it might appear that the Atlantic division was likely to be behind the Pacific in completion. The Pacific division, however, includes the Pedro Miguel and Miraflores locks and its record of last year's work is swelled by the amount excavated in the lock pits. Further than this, on the Pacific sea level section there is a considerable amount of rock which is to be laid dry and excavated with steam shovels after the material over it is removed by the hydraulic excavation now in progress. This work must, of course, be all completed before the canal can be opened.

On the Atlantic section the only steam shovel work in rock, that through the Mindi Hills, is now nearly completed. All the rest of the work is being done by dredging. The Atlantic section of the canal can be opened and used for traffic, therefore, at any time when the rest of the works are ready, even if the channel on this section, is not completed to its full depth and width.

So much for the work of excavation. The two remaining parts of the canal work of chief importance are the dam construction and the lock construction.

The dams at the Pacific end are of moderate size and except for the concrete dam on the east side of the Miraflores locks, which will have to be among the last pieces of work undertaken, they can all be completed at an early day. The great earth dam at Gatun is so far advanced that it can be brought up to the highest



Full Line shows Rainfall at Empire ; Dotted Line shows average Rainfall for Central Division.

FIG. 3. DIAGRAM SHOWING PROGRESS OF EXCAVATION BY MONTHS ON CENTRAL DIVISION OF PANAMA CANAL, WITH AVERAGES OF COST AND RAINFALL RECORDS.

1904, TO FEB. 1, 1911. LIEUT.-COL. D. D. GAILLARD, Division Engineer.

Cost per cu. yd., direct charges					Overhead charges.				Plant arbitraries.		Grand Totals.		Percentages.			Aver-	Lo- co's	Cu. yds. per loco.	Cost per loco.
Div. struct.	Divi- sion.	Con- tract.	Total unit cost.	Total direct charges.	Gen'l ex- pense.	Admin.	Total per unit.	Total amount.	Per unit.	Amount.	Per unit.	Amount.	Direct cost.	Over- head.	Plant.	age rain- fall.	in ser- vice.	per day.	per day.
.0270	1.3944	.....	$1.3944	$11,262,121.68	.0710	.....	.0710	$573,294.98	.1300	$1,049,922.51	1.5954	$12,885,339.17	87.40	4.45	8.15	5.21	No data available		
.....	.9040	.....	.9040	696,577.37	.0973	.....	.0973	74,993.52	.1300	100,174.10	1.1313	871,744.99	79.91	8.60	11.49	9.56	162	224	69.57
.....	.9092	.....	.9092	718,061.20	.2489	.....	.2489	196,275.93	.1300	102,669.58	1.2881	1,017,006.71	70.61	19.29	10.10	11.93	157	231	73.90
.....	.9290	.....	.9290	719,942.52	.2262	.....	.2262	175,310.03	.1300	100,751.82	1.2852	996,004.37	72.28	17.60	10.12	11.97	164	259	81.79
.....	.9431	.....	.9431	811,200.64	.2346	.....	.2346	201,784.86	.1300	111,816.38	1.3077	1,124,801.88	72.12	17.94	9.94	18.20	158	249	90.40
.....	.9374	.....	.9374	782,494.58	.1636	.....	.1636	136,573.67	.1300	108,507.88	1.2310	1,027,576.13	76.15	13.29	10.56	10.73	156	258	79.78
.....	.7304	.....	.7304	821,214.45	.2081	.....	.2081	233,893.59	.1300	146,137.81	1.0685	1,201,161.85	68.37	19.46	12.17	3.38	160	328	75.78
.....	.6269	.....	.6269	875,418.40	.1804	.....	.1804	251,969.24	.1300	181,540.97	.9373	1,308,928.61	66.88	19.25	13.87	1.04	159	408	73.92
.0005	.6032	.....	.6032	874,364.41	.1931	.....	.1931	279,027.76	.1300	188,293.30	.9263	1,341,685.47	65.17	20.79	14.04	.37	156	450	70.25
.0007	.5425	.....	.5425	877,605.62	.1272	.....	.1272	204,280.12	.1300	209,083.34	.7997	1,291,881.08	67.94	15.81	16.25	.87	156	470	71.74
.0001	.5759	.....	.5759	905,615.93	.1477	.....	.1477	232,107.14	.1300	204,367.41	.8536	1,342,090.48	67.48	17.29	15.23	2.03	156	471	71.94
.....	.7448	.....	.7448	891,469.64	.2056	.....	.2056	245,983.72	.1300	155,576.46	1.0804	1,293,029.82	68.95	19.02	12.03	14.70	150	355	74.20
.....	.6115	.....	.6115	890,583.95	.2562	.....	.2562	373,144.60	.1300	189,303.01	.9977	1,453,031.56	61.29	25.68	13.03	10.58	148	436	72.27
.0002	.7128	.....	.7128	9,864,548.71	.1882	.....	.1882	2,005,269.13	.1300	1,799,104.06	1.0310	14,268,921.95	69.13	18.26	12.61	7.95	157	347	74.92
.....	.5757	.....	.5757	844,681.50	.1340	.....	.1340	196,564.21	.1300	190,720.66	.8397	1,231,966.37	68.57	15.95	15.48	10.36	201	331	66.90
.0002	.6174	.....	.6174	951,148.76	.1292	.....	.1292	199,046.99	.1300	200,279.30	.8766	1,350,475.05	70.43	14.74	14.83	11.93	201	344	74.77
.0020	.6365	.....	.6365	935,563.39	.1543	.....	.1543	226,819.63	.1300	191,073.04	.9208	1,353,458.06	69.12	16.77	14.11	9.61	186	342	80.16
.0004	.5533	.....	.5533	877,065.12	.0887	.....	.0882	139,691.67	.1300	206,051.56	.7715	1,222,808.35	71.72	11.43	16.85	11.15	190	348	68.05
.0005	.5822	.....	.5822	791,175.48	.1071	.....	.1071	145,576.24	.1300	176,665.58	.8193	1,113,367.30	71.06	13.07	15.87	10.71	183	354	76.03
.0003	.5812	.....	.5812	926,538.73	.0850	.....	.0850	135,444.86	.1300	207,219.22	.7962	1,269,202.81	73.00	10.67	16.33	5.68	186	356	71.28
.0002	.5656	.....	.5656	870,821.01	.1335	.....	.1335	205,550.19	.1300	200,154.24	.8291	1,276,505.44	68.22	16.10	15.68	4.28	186	353	69.92
.0009	.5018	.....	.5018	825,212.82	.0890	.....	.0890	146,394.61	.1300	213,802.68	.7208	1,185,410.11	69.61	12.35	18.04	2.97	182	406	71.43
.0007	.4490	.....	.4490	922,261.06	.0776	.....	.0776	159,520.68	.1300	267,031.44	.6566	1,348,813.18	68.38	11.83	19.79	1.20	191	432	63.88
.0018	.4549	.....	.4549	811,077.02	.0881	.....	.0881	156,913.39	.1300	231,759.58	.6730	1,199,749.99	67.60	13.08	19.32	4.60	186	440	66.12
.0015	.6045	.....	.6045	914,500.74	.1028	.....	.1028	155,717.60	.1300	196,707.29	.8373	1,266,925.63	72.18	12.29	15.53	10.09	185	344	71.14
.0055	.5605	.....	.5605	850,888.20	.0888	.....	.0888	134,771.50	.1300	197,344.42	.7793	1,183,004.12	71.92	11.39	16.69	11.46	191	361	71.51
.0012	.5517	.....	.5517	10,520,933.83	.1049	.....	.1049	2,001,941.57	.1300	2,478,811.01	.7866	15,001,686.41	70.13	13.35	16.52	7.84	189	367	70.83
.0022	.6200	.....	.6200	889,406.46	.....	.....	.....	.....	.1300	186,514.25	.7500	1,075,920.71	82.66	....	17.34	10.23	162	365	81.59
.0008	.5714	.....	.5714	802,823.01	.0999	.0084	.1083	152,095.78	.1300	182,638.69	.8097	1,137,557.48	70.58	13.37	16.05	8.87	162	364	78.58
.0001	.5503	.....	.5503	809,918.35	.0838	.0053	.0891	131,079.24	.1300	191,333.48	.7694	1,132,331.07	71.53	11.58	16.89	9.90	158	405	79.39
.....	.5235	.....	.5235	798,012.12	.0909	.0080	.0989	150,793.74	.1300	198,160.30	.7524	1,146,966.16	69.58	13.14	17.28	17.43	158	402	74.30
.0007	.6044	.....	.6044	703,814.00	.1089	.0078	.1167	135,834.47	.1300	151,373.43	.8511	991,021.90	71.02	13.70	15.28	28.42	144	337	83.06
.0011	.6102	.3500	.6088	765,313.99	.1078	.0051	.1129	141,952.72	.1300	163,418.58	.8517	1,070,685.29	71.48	13.26	15.26	14.93	144	355	75.31
.0004	.5389	.3500	.5347	801,835.10	.0457	.0033	.0490	73,424.23	.1300	194,934.35	.7137	1,070,213.68	74.92	6.87	18.21	2.22	142	413	83.61
.0075	.4757	.3500	.4730	731,073.24	.0500	.0031	.0531	82,021.01	.1300	200,912.65	.6561	1,014,006.90	72.10	8.09	19.81	2.34	152	431	80.77
.0007	.4054	.3500	.4045	806,803.84	.0334	.0028	.0362	72,070.31	.1300	259,294.62	.5707	1,138,168.79	70.89	6.33	22.78	4.01	151	483	70.20
.0005	.5162	.3500	.5140	882,879.34	.0378	.0030	.0408	70,112.98	.1300	223,290.86	.6848	1,176,283.18	75.06	5.96	18.98	5.40	157	416	77.42
.0003	.6161	.3521	.6130	826,418.74	.0464	.0038	.0502	67,698.85	.1300	175,272.89	.7932	1,069,390.48	77.28	6.33	16.39	11.43	151	354	80.53
.0017	.5526	.3500	.5503	808,760.74	.0476	.0040	.0516	75,727.23	.1300	191,038.90	.7319	1,075,526.87	75.20	7.04	17.76	11.60	143	384	72.31
.0013	.5416	.3501	.5399	9,627,678.93	.0602	.0044	.0646	1,152,810.58	.1300	2,318,183.00	.7345	13,098,672.51	73.50	8.81	7.69	10.56	152	392	79.03
.0013	.6217	.3500	.6198	818,006.83	.0407	.0036	.0443	58,495.01	.1000	131,991.60	.7641	1,008,493.44	81.11	5.80	13.09	15.78	146	359	81.02
.0015	.4910	.3500	.4906	790,895.18	.0456	.0040	.0496	79,948.34	.1000	161,211.80	.6402	1,032,055.32	76.63	7.75	15.62	11.62	147	405	67.60
.0005	.4856	.....	.4856	764,478.76	.0474	.0045	.0519	81,684.83	.1000	157,423.80	.6375	1,003,587.39	76.17	8.14	15.69	12.99	147	424	76.49
.0007	.5053	.2100	.5046	803,156.72	.0421	.0034	.0455	72,397.85	.1000	159,172.30	.6501	1,034,725.87	77.62	7.00	15.38	14.21	147	419	78.92
.0003	.5101	.2100	.5092	748,668.14	.0472	.0026	.0498	73,166.93	.1000	147,043.60	.6590	968,878.67	77.27	7.55	15.18	14.75	148	406	84.14
.....	.5593	.2107	.5590	783,278.89	.0482	.0056	.0538	75,870.80	.1000	140,888.10	.7098	1,000,037.79	78.32	7.59	14.09	15.25	146	365	81.06
.0001	.4963	.2118	.4934	795,280.58	.0370	.0030	.0408	65,727.90	.1000	161,177.90	.6342	1,022,186.38	77.81	6.43	15.76	.28	150	426	77.71

lake level as soon as the progress on the locks and the excavation will permit Gatun Lake to be filled.

There is a low dike to be built in a saddle on the divide between the Trinidad Valley and the Caribbean. This will not be undertaken until Lake Gatun is partly filled, so that the materials and working force to build this dike can be transported by water up to the site.

Turning now to the work of lock construction; it is barely two years ago that the prophets of calamity were still turning out direful predictions as to the troubles and delays which would be experienced in the lock construction.

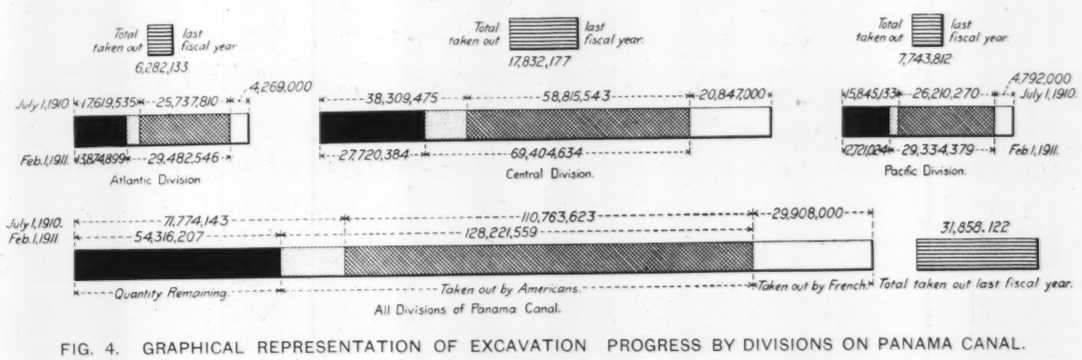


FIG. 4. GRAPHICAL REPRESENTATION OF EXCAVATION PROGRESS BY DIVISIONS ON PANAMA CANAL.
(Corrected to Feb. 1, 1911.)

And these predictions were not wholly unreasonable. It was in June, 1904, that we took possession of the canal work, but it was not till the spring of 1906 that the lock plan of construction was definitely decided upon.

After that the excavating plant and machinery had to be marshalled and the lock pits excavated and the elaborate plant necessary for constructing the locks had to be planned, and constructed. Thus it was not till August, 1909, that the first concrete was laid at Gatun, and it was nearly the end of the year before the concrete work there was in full swing.

At the Pacific end even a greater time was required to get the concrete work under way, due chiefly to delays of the contractors for furnishing the concrete handling cranes.

To a large degree these lock building plants were novel and unprecedented. Carefully planned though they were, it remained to be demonstrated what rate of output they could attain.

Further, the locks themselves at Panama are not only far larger but more complicated than any canal locks ever built. The use of power for moving every part of the lock machinery and the extent to which safeguards have been provided to meet every possible contingency has made the lock-walls a labyrinth of culverts and chambers for machinery. It would have been impossible to have built these locks of stone masonry except with an expenditure of time as well as money, which would have made the lock plan as now being carried out almost an impossibility. Even with the use of concrete it seemed two years ago that the progress might be so retarded by the time required to build and place the many complicated forms for the culverts, machinery chambers, etc., that the estimate of time for completion might be far astray.

It is, therefore, exceedingly gratifying to see the remarkable speed with which the concrete is being placed. The upper Gatun locks, where concrete laying began less than two years ago, in August, 1909, are now 95 per cent. completed. In the middle locks about half the concrete has been laid. The lower lock, which has to have foundations laid at a depth of some 45 ft. below sea level, has been delayed by the repeated sliding into the pit of the soft material overlying the rock; but its excavation is now practically completed and concreting is going on over a large part of its area. Comparing the volume of concrete still to be laid at Gatun with the rate of progress maintained during the past year, it is evident that Jan. 1, 1913, will see the concrete work at the Gatun locks practically done, with the possible exception of a small amount of finishing work about the top.

The engineers responsible for the work on the Pacific locks have been handicapped by the contractor's delay in furnishing the concrete handling cranes and also by the fact that the Pacific locks are not in one flight as at Gatun, so that two distinct construction plants are necessary.

It is interesting to recall how much was said a few years ago in criticism of the adopted plans because the three locks at the Atlantic end were in a continuous flight. Yet anyone can see now that there is a great advantage in this arrangement, both in time and cost of construction and in convenience for ships after the locks are completed, over the arrangement at the Pacific end, where the locks at Pedro Miguel are a mile distant from the two lower locks at Miraflores. It should be said, however, that this separation of the upper locks from the two lower ones at the Pacific end was made necessary by the level of the rock available for foundations, and the general topography.

To return, however, to the progress on these Pacific locks: In the locks at Pedro Miguel about

70% of the concrete has now been laid. At Miraflores only about 12% of the concrete is in, but the work is in such shape that an exceedingly rapid rate of construction from this time onward may be confidently predicted. It does not seem probable that the Pacific locks can be completed as soon as the locks at Gatun by reason of the handicaps before mentioned, yet the work upon them will not be many weeks behind the other in finishing.

The erection of the lock gates is the next task to be undertaken. This work, which is to be done by the gate contractors, the McClintic-Marshall Construction Co., is just now beginning. There are 46 pairs of gates to be erected or 92 gate leaves. These leaves vary from 47 ft. to 82 ft. in height. The highest leaves weigh 1,483,700 lbs. each and the total amount of steel in all the gates is 59,244 tons. This is an enormous amount of material to erect, especially as nearly all of it is plate work, and requires calking as well as riveting and very thorough painting in enclosed spaces. As it is repetition work, however, rapid progress can be made upon the erection work by concentrating a sufficiently large force upon it so that a considerable number of the gates may be undergoing erection at one time. The lock masonry is far enough advanced so that the gate contractors can have places for work upon the gates as fast as they have the men and material ready. The contract date when gate erection is to be completed is Jan. 1, 1914.

The final work to complete the locks will be the erection of the machinery to operate the lock gates, to operate the Stoney gate-valves controlling the flow of water through the main culverts, the cylindrical gates controlling the passages from the culverts in the lock-walls to the passages under the lock floor, the gate locking machinery and the electric towing locomotives which will run on rack rails laid on the lock walls and will haul vessels in and out of the locks.

All of this machinery is to be electrically operated, and over a thousand electric motors are required for the equipment of all the locks. Some of this machinery is under contract and most of the remainder of the designs are completed and the contracts are to be let in a short time.

The manufacture of this machinery should not involve an excessive amount of time but some delays may be experienced in its erection as there is so much of it to be placed. It will require a good deal of accurate and skilled work and to a considerable extent the work has to proceed in sequence. That is, certain machines cannot be placed until others are in position. The engineers responsible for the design of this machinery have given thorough study to the problem of rapid erection and the avoidance of conflict between different parts of the work and are as eager to make a record for rapid completion as those engaged in other departments. The novel and complicated character of their work, however, affords a larger opportunity for unforeseen delays than occurs elsewhere; and it remains to be seen how well experience will verify their calculations.

The general public at home reads of the digging of the Panama Canal and thinks that rapid work upon it and early completion means only "making the dirt fly." But the really big problem of those responsible for direction of the work who are striving for early completion is to keep all the different departments of the work moving in harmony, so that one will not be delayed by another and so that all may finish as nearly as possible at the same time.

It is never possible to do this perfectly. There will always be some interference; but thus far on the Panama canal work it has apparently been kept down to very small proportions. The severest test of the organization, however, will come as the work approaches completion and the finishing work on the masonry, the lock gate erection and lock machinery erection must all go on together. The success thus far attained, however, gives every reason to expect that a good degree of "team work" will be maintained during the remainder of the construction.

THE INFLUENCE OF CURRENT BRIDGE INSPECTION on bridge design should be greater than it is, according to the following discussion by Prof. H. S. Jacoby, of Cornell University, at the recent annual meeting of the American Railway Engineering Association:

In connection with steel bridges, there is hardly any material available in published form relating to the lessons taught by the observation of bridges under traffic conditions. All over the country bridge inspectors are making their rounds, looking at the details of bridges and making records of conditions discovered and recommendations as to repairs required. After the repairs are made the incident is closed for that structure, and so the matter goes on year after year. There must be some important lessons taught by the extensive experience of these inspectors which should influence design much more largely than it apparently does.

One reason is that the maintenance department is entirely separate from the bridge department, in which the designs of new structures are developed. There are doubtless also other influences at work. Designers and draftsmen have but little opportunity to become familiar with these matters by direct observation. It seems that the railway does not get the full benefit of the experience of the maintenance department, thus leading to the continued construction of some faulty details because the designers do not learn (except incidentally) of the actual behavior of bridges previously designed by them.

For example, certain designs of brackets on end floor beams perform their duty in an excellent manner under heavy modern live loads, and under adverse conditions of adjacent track, while others show marked defects. Yet the defective designs are built over and over again on the roads in which the maintenance-of-way department has discovered their weakness.

This condition is not confined to steel bridges. I am convinced that some railways are losing at least two or three years of service in their Howe trusses because of the lesser relative efficiency of the splices in the lower chords. This is an indication that there are details in timber framing which are not receiving sufficient study by designers, although similar timber structures have been used for many years. This is probably true because the conditions under which failure occurs are not brought to the attention of designers.

A 1,000-HP. Multi-Stage De Laval Turbine With Speed Reducing Gear.*

It is generally admitted that the large sized steam turbine has found application only for driving alternating-current generators and for the propulsion of ships. Comparatively little progress has been made in its use with direct-current generators, for direct connection to moderate-speed machinery, or for rope and belt drives. In spite of its economical performance, simplicity, small weight and space factors, etc., the methods of speed reduction have been either insufficient or unsatisfactory to the prospective users.

The many types of turbines now on the market have arisen from attempts to solve the problems of speed reduction. One of the simplest proposals has been to increase the diameter of the wheel. This has been repeatedly suggested but actually this demands a wheel of prohibitive size from standpoints of strength of materials, space, windage friction, etc.

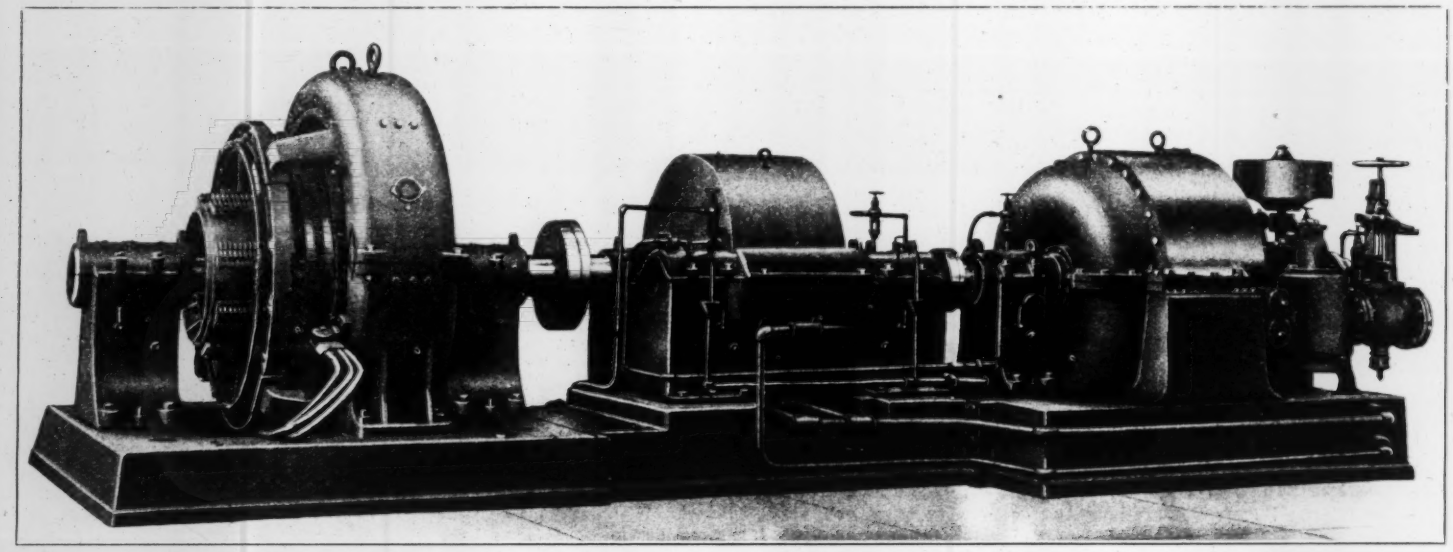


FIG. 1. MULTI-STAGE, SINGLE-GEARED, DE LAVAL STEAM TURBINE.
(Driving a 500-KW., 500-r. p. m. direct-current generator.)

The next most simple means has been the use of reduction gears such as were employed by De Laval some 30 years ago, almost at the inception of his work on the steam turbine. These gears have proven satisfactory to the De Laval company in sizes up to 750 HP. The size limitation below this of the older types of single-stage geared De Laval turbines was not, as commonly assumed, on account of the gear. It was found that, unless the blades were very long or the angle of entrance was increased, the capacity of the turbine wheel was limited by the area available for the nozzle outlets. (It is to be remembered that at the outlets these nozzles must have an area corresponding to the final volume of steam expanded to the pressure of a 28-in. vacuum for a condensing machine.) If the length of blades be over-increased, to increase nozzle openings, the blades soon reach the limit of strength at the root to withstand the centrifugal-force stresses.

The third scheme for speed reduction lies in the use of multiple stages—with blades, buckets and nozzles variously in series. In one type, the aim would be to expand in a single nozzle to final pressure and reduce the velocity by passing through buckets and deflecting blades alternately. In another type the deflecting blades would all be replaced by expanding nozzles. In a third type only a few rows of the deflecting blades would be replaced by nozzles. In still another type the pressure reduction is not confined to the stationary nozzles or blades but occurs in both.

The speed reduction of the first type, over a single-stage impulse wheel, depends directly on the number of rows of moving buckets; for a

*Description prepared by Mr. G. H. Gibson for the De Laval Steam Turbine Co., Trenton, N. J.

1 to 1 reduction four rows would be needed. As the velocity of moving steam varies as the square root of the energy converted into motion, if it was desired in the second type to reduce the velocity of steam per stage to one-fourth that of a single-stage wheel, then each stage would have to permit one-sixteenth the total energy conversion of the single-stage wheel and there would need to be 16 stages. In the third type reduction this would be accomplished with four pressure stages having each two impulse sections. In the fourth type (the "reaction" turbine) the steam enters the bucket with nearly zero velocity, relative to the bucket, in the direction of bucket motion and the propulsive force is obtained from the reaction of the jets escaping from the lower-pressure side of the buckets. The buckets would move with a velocity equal to that of impinging steam, but the total energy drop is divided into twice as many parts as there are moving rows of buckets since each row of stationary blades and of moving buckets is a pressure stage. Since the buckets in the single-stage impulse wheel move half as fast as the impinging steam and in the "reaction" type move as fast, then for a 4 to 1 speed reduction it will be necessary that the impinging velocity (spouting velocity from the nozzle) be one-eighth that of the single-stage impulse type. Moreover, as this spouting velocity varies as the square root of energy change (from pressure to velocity form), the energy drop per stage would be one-sixty-fourth the whole and 64 stages or 32 rows of moving buckets would be needed.

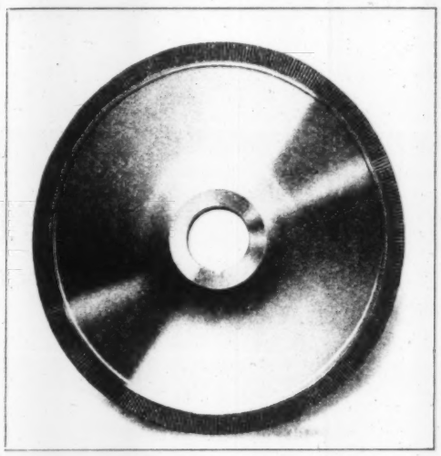


Fig. 2. A Single Wheel.

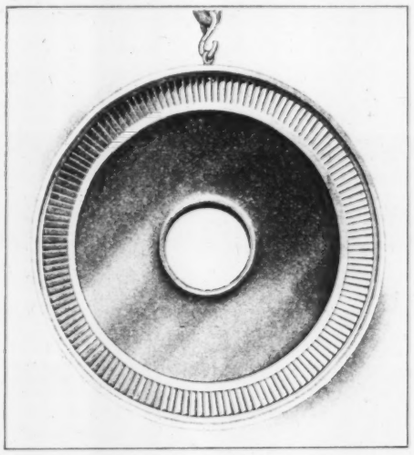


Fig. 3. One Diaphragm.

FIGS. 2 AND 3. A WHEEL AND DIAPHRAGM FROM A DE LAVAL MULTI-STAGE TURBINE.

All these forms of turbines have objections for great speed reductions. In the first multi-stage type noted there is an excessive loss of velocity due to friction in passing through the long series of fixed and movable buckets. This inefficiency is checked in the third type by eliminating the highest velocities. In the second type the skin friction of the greater number of disks rotating in steam at comparatively high pressure is considerable and there may be leakage of steam along the shaft from one stage to another. The fourth type, in addition to excessive skin-friction loss from too many rows of buckets, has a leakage of steam through the clearances at the ends of the blades since there is a difference of pressure between the two sides of each blade. This clearance must often be large, with a long shaft carrying many rows of blades, to care for vibration, expansion, etc.

It is evident that any pure multi-stage turbines are out of question for a moderate speed like 600 r. p. m. The number of stages is so great that the shafts would be long and subject to vibration. Difficulties would be found in regard to clearance, both from springing of the shaft and from unequal contraction and expansion of shaft and casing, not to mention increased cost, lower efficiency, etc. For this reason, it has been common practice to give over the attempt to force down the speed of the turbine after a certain point and instead to endeavor to bring up the speed of the driven machine. This has been successful in the case of the alternating-current generators, although the speeds ordinarily seen here, from 1,500 to 3,600 r. p. m. for units below 7,000 HP., have required long drums and have introduced difficulties in balancing, in overcoming vibration, in securing good insulation, ventilation, voltage regulation, etc., which have had to be carefully studied. It is with the direct-current generators that the disadvantages of such high speeds become most serious. Many designers believe that the speed of a direct-current generator of 1,000-KW. capacity (often requiring a 2,000-HP. turbine to carry overload) or over, should not exceed a speed limit of 600 r. p. m., and that such a speed is desirable for sizes above 500 KW.

The De Laval company has developed a compromise design, shown in the accompanying figures, in which a moderate number of pressure-reduction stages have been employed, the desired speed reduction being completed by a single helical reduction gear in rigid bearings. Fig. 1 shows a 1,000-HP. (at maximum overload on generator) non-condensing unit driving a standard-speed direct-current generator (Crocker-Wheeler Co.). The turbine-wheel shaft revolves at 3,600 r. p. m. and the generator shaft at 500 r. p. m.

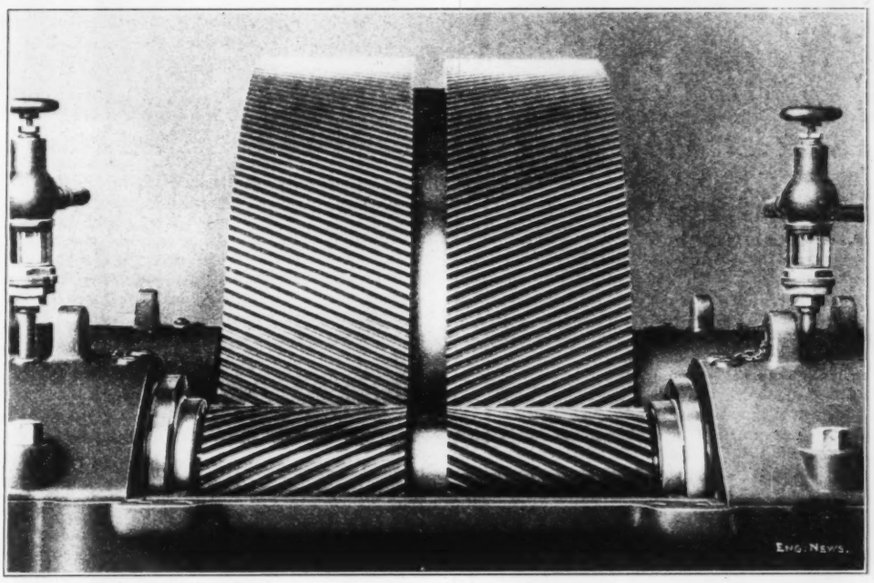


FIG. 4. 1,200-HP. HELICAL GEAR AND PINION WITH CASING REMOVED.

The main casing consists of cast iron and is approximately cylindrical in shape, being split horizontally so that the top half may be lifted off to give access to the revolving and stationary members of the turbine. The casing is supported on a level with the center of the shaft by two pedestals rising from the bed plate, one on each side, and is bolted down only at one end, being free to expand and contract in an axial direction between steel guides. As the endwise position of the shaft is also determined by a thrust bearing at the same end, the results of axial expansion are largely compensated for.

Steam is admitted to the turbine first through a strainer case and then through a combined trip and throttle valve, shown at the extreme right. It passes through the adjacent governor valve and through steam nozzles of the standard De Laval type, impinging upon the blades of the first-stage wheel. Partial admission is used in the first stage, but full admission in later stages. The wheels are of the familiar De Laval type. Upon rebounding from the moving blades the steam again expands in passing between the guide vanes placed all around the periphery of the diaphragm between the first stage and the second stage. The number of stages varies from four to ten according to the service and operating conditions imposed.

The buckets on the wheels are drop forged from bars of non-corrodible metal and are used with the glossy surface untouched as they come from the drop forges. Such buckets, it is found, wear much more satisfactorily than machined buckets, since they present a smoother surface initially, and if they receive only dry steam their life is almost unlimited. The use of a special metal also avoids the rusting which has been the cause of serious annoyance with steel buckets and even with mild nickel-steel buckets, whereas high nickel-steel buckets have shown a tendency to become brittle and to break unexpectedly. The buckets are dovetailed into the rim of the wheel-disk.

The wheels are turned up from solid forged disks of Swedish steel and are mounted upon the shaft by split taper sleeves, drawn tightly into place by internal nuts in the wheels. After the wheels are assembled, a lock nut on the shaft serves further to secure them, while rotation of the wheels about the shaft is prevented by a key. The greater blade length required by the increased volume of the steam as it proceeds towards the exhaust is compensated for by slightly reducing the early diameters of the disks and by increasing the bore of the casing.

The stationary blades are made of "extruded" bronze and are pinned onto the cast-iron diaphragm. The diaphragm itself is slightly dished

in order to increase its strength to withstand pressure and to complete it, a steel band is shrunk over the tips of the blades (see Fig. 3). The steel band is slightly wider than the blades and diaphragm and as adjacent bands touch each other, a complete casing is formed which would effectually prevent the possible penetration of parts in case of rupture of the wheels. The diaphragms and wheels are assembled together about the shaft and the diaphragms are adjusted to properly clear the wheels after lifting the whole into the casing. In very large designs the diaphragms are split and held in alinement with tongue-and-groove joint to facilitate assembly. The center of the diaphragm is perforated for the passage of the shaft and leakage of steam is prevented by labyrinth packing.

The packings surrounding the shaft at the high-pressure and low-pressure ends are more elaborate. The high-pressure packing, which is called upon to withstand a pressure of about 275 lbs. gage, consists of a long labyrinth, followed by four carbon packing rings. Any steam leaking by the labyrinth packing is piped to one of the intermediate stages of the turbine and utilized, while any steam leaking by the first carbon ring is taken to the exhaust outlet. The packing at the exhaust end of the turbine consists of three carbon rings, steam at reduced pressure being led in between the first and second ring from the outside, which is also done at the high-pressure end. This insures that any leakage into the exhaust when vacuum is carried will be of steam, not of air.

The bearings of the turbine proper are of the split, Babbitt-lined type and are supplied with oil through sight-feed oilers from a geared pump in the base of the governor.

The governing mechanism is in duplicate, that is, there is a speed-regulating governor and a speed-limiting or emergency governor. The former is mounted at the top of a vertical shaft driven by a worm gear from the turbine shaft. It is of an extra heavy, substantial type and controls, through a system of two bell-crank levers and a connecting rod, the movement of a vertical double-seated poppet valve similar to that used on older De Laval turbines. In order to prevent damage to the valve by overtravel of the governor, a spring is inserted in the connecting rod. The same worm which meshes with the worm wheel on the governor shaft, meshes with another worm wheel driving the tachometer, which is supplied as a permanent and regular part of the equipment. The lower end of the governor shaft is connected to the oil pump, supplying the bearings of the machine and the pinion and gear. The emergency governor is located in the end of the turbine shaft itself and is ordinarily not in contact with the trip. Upon touching the latter steam pressure is at once released from underneath a piston, by means of which a toggle gear is released, allowing the combined trip and throttle valve to close under the pressure of the steam in the supply pipe. This trip may also be sprung by hand, if desired, while the valve spindle is also furnished with a hand wheel and is threaded, so that it may be used as a throttle valve independently of the trip.

The pinion and gear, perhaps the most important and interesting part of the construction, are shown in Figs. 4 and 5. The gear is of the double helical or herring-bone type, with involute teeth having an angle of about 20° to the axis, and differing from the standard gears supplied with De Laval turbines only in size. The pinion is

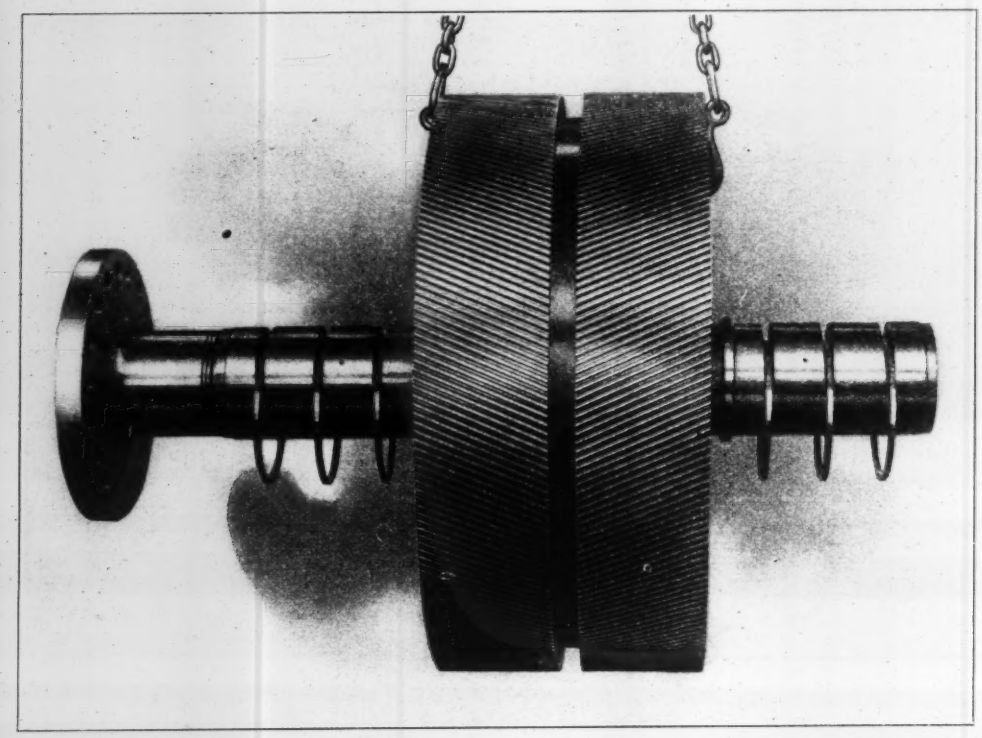


FIG. 5. HELICAL GEAR OF DE LAVAL TURBINE; ASSEMBLED WITH SHAFT, BEARINGS AND COUPLING.

cut from a solid bar of steel and is carried in plain Babbitted bearings supported in a rigid cast-iron frame, which also supports the gear bearings. The pinion bearings are lubricated by sight-feed oilers from the pump system before referred to, the excess oil overflowing to the wells of the gear bearings, which are ring oiled. The gear consists of a solid cast-iron center upon which are shrunk two thick steel rings. The hub is mounted on a stiff shaft, which carries at one end a half of the flexible coupling for connection to the driven machine. The gear, with shaft, bearings and coupling is shown by Fig. 5.

No attempt is made to employ a thrust-compensating or other self-adjusting frame for the gear or pinion bearings. It has been found possible to cut the teeth so accurately that such devices are superfluous—a conclusion which is corroborated by Mr. Parsons' results in building a 9000-HP. gear of the same general type for the "Vespasian."

The familiar arrangement of double gears with a single pinion seen in earlier De Laval designs is not needed with this multi-stage construction. The double gears were employed on account of the very high speed of the single-stage turbine to reduce the thrust of the pinion on the shaft bearings, the downward thrust from meshing with one gear being fairly balanced by the upward thrust from meshing with the other.

Years of experimental work have been necessary to increase the accuracy of the gears before they could be made satisfactory for such heavy service above 750 HP. The need of special effort in this direction is shown for instance by the fact that several months of continuous work by a skilled machinist were required for the correction of a lead screw purchased from one of the best shops in this country, before it was sufficiently accurate to be used in the gear-cutting machine on which were produced the gears for the unit described above. To secure uniformity in the worm wheels of this gear cutter it was necessary to go to the refinements practiced in making similar parts of astronomical apparatus.

The gear and pinion mesh from below. The lubrication of the teeth is secured by jets of oil directed at the line of contact on the entering side. This oil after use is passed through an oil strainer located in the base of the turbine, then through a cooling and settling chamber and then to the oil well, from which it is again pumped through the circuit.

The operation of the turbo-generator above described is remarkably free from vibration and noise. As it stood on the test floor, supported upon small screw jacks, without steadying, it was impossible to tell a few yards away whether or not the turbine wss running without watching the moving parts. There is no vibration and no noise that may be overheard at a short distance.

It might be said, in passing, that the efficiency of such gearing as here described can be determined with reasonable accuracy without the use of expensive brakes to absorb and measure the power transmitted.

Since all energy lost in friction in the gear must be converted into heat, the measurement of the heat emanating from the gear case will give an accurate measure of the loss of energy in the gears. Such measurement of the heat is not difficult. The radiation from the casing can be determined accurately for any given temperature by observing either the rate of cooling under fixed conditions or by keeping the casing warm by means of hot water or steam. The amount of heat removed from the gears by the lubricating oil is even more easily determined by measuring the inlet and outlet temperatures and the weight of oil used per minute or per hour.

BOTTLE-MAKING MACHINES, according to Mr. Bernard A. Kupferberg, of London, England, have only recently been sufficiently perfected to enable them to compete with manual labor. The following description of bottle-blowing machinery is taken from Mr. Kupferberg's paper on "The Manufacture of Glass Bottles," read in October, 1910, before the Junior Institution of Engineers:

Machines for the manufacture of bottles have formed the subject of many inventions, the most important of which are those by Ashley, Owens, Bouchet, Severin, and Cox. The principle of all of them is to cast a stick or bar in a mold, one end of which forms the mouthpiece of the bottle. A punch or pin is inserted through the mouthpiece part of the mold, thus partly hollowing the bar. The mold is then removed; a second one, with the full shape of the bottle, takes its place, and the tube is inflated into the desired shape. The glass, in most of the machines mentioned, is filled into the tube-mold by manual labor, that is to say with a scoop.

Cast iron is usually the material from which the molds are made. The bottles supply enough heat to the molds to prevent their being cooled too quickly. The pressure required in bottle machines varies, according to the glass used, from 10 to 30 lbs. per sq. in.

By far the most ingenious is the Owens' machine, having six sets of molds fixed to a frame revolving on a vertical axis. A small ante-chamber, the base of which is formed by a revolving fire-proof clay tub, is attached to the furnace. The latter supplies the revolving tub with glass, the object of its motion being to constantly supply new glass to the machine.

Separate burners are arranged round the chamber for the purpose of maintaining the temperature of the glass in the tub. On one side of the chamber the tub projects several inches, and into this the end of each one of the tube molds is dipped, and is there filled by suction. During the revolution of the frame the various stages of formation (the replacement of the molds, the inflation, etc.) are gone through, and shortly before a mold re-arrives at the tub, it opens and deposits its bottle, bottom upwards, into a funnel, through which the bottle slides to a small stove for the so-called "fire-finish." In the stove, it is exposed to a high temperature, which brings the glass near the melting-point, thereby removing any tension in the neck or mouthpiece caused by the insertion of the cold pin in the beginning of its formation. Six sets of molds are fixed to the revolving frame, each revolution of the latter therefore producing six bottles. On leaving the "fire-finish" stove the bottles are placed in the annealing stove.

The Owens' machine turns out 14,000 to 16,000 bottles per 24 hours. Twelve of these machines are now in satisfactory use in Europe.

Inflating hand-made bottles by mechanically compressed air has frequently been tried, but always with indifferent success. The even distribution of the glass in the walls of the bottle largely depends on the pressure used, and this can be adjusted evenly by the lungs, but not so by the means of mechanically compressed air.

Razing a Seven-Story Reinforced-Concrete Office Building.

After the great Baltimore fire of February, 1904, one of the first buildings to be erected on the site of one destroyed in the conflagration was that occupied by the Baltimore "News" at the southeast corner of Fayette and Calvert Sts., in the heart of the business district. Having in mind the very destructive effect of the fire on all but the most fire-proof of the buildings exposed to the flames, the owners of the "News" building, decided to erect one of the then comparatively novel reinforced-concrete type and accordingly immediately set to work to build one of the heaviest reinforced-concrete office buildings then in existence. In the seven years that have since elapsed, the business of the paper has grown to such an extent that a much larger structure is now needed and this fact, together with the desirability for office buildings in this section of the city, has led the present owner of the "News," Mr. Frank A. Munsey, to undertake the erection on the same site of an 18-story skeleton steel office building. This new building is of such dimensions that it is necessary to remove entirely all of the old building. The razing of a seven-story reinforced-concrete structure is entirely new in the history of the industry and the methods used in its destruction as well as the condition of the material in the building are both of exceptional interest.

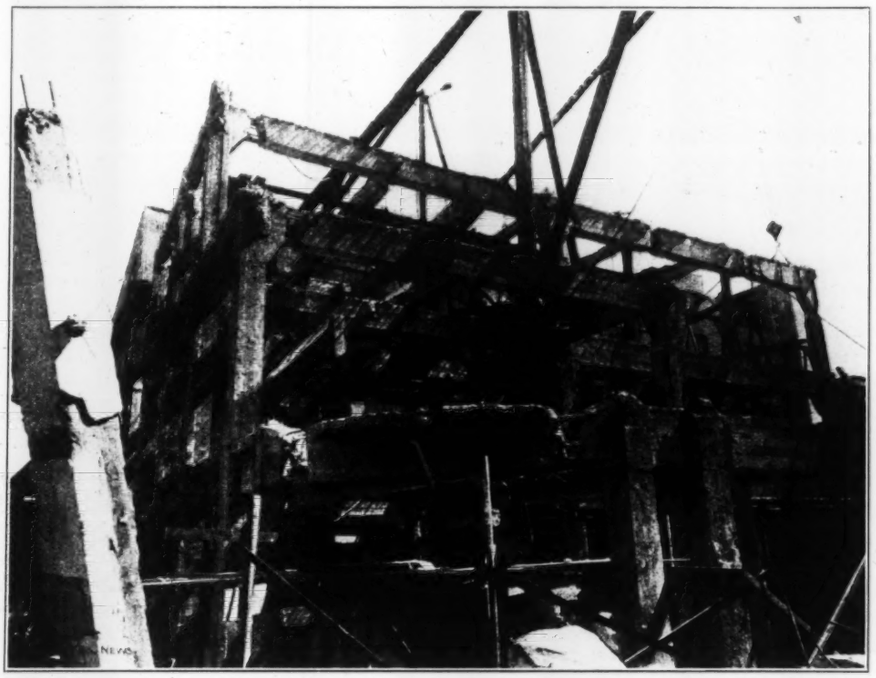


FIG. 1. TEARING DOWN A REINFORCED-CONCRETE BUILDING.

[View taken March 24, 1911. Looking southeast toward northwest corner of building. The corner beam in the immediate foreground is beam "3" of the second floor, shown in Fig. 2.]

The site to be occupied by the new building, which will be known as the "Munsey Building," extends for 102 ft. on Calvert St. and 138 ft. on Fayette St. Of this area the corner 73 ft. 5½ ins. on Calvert St. and 57 ft. 3¾ ins. on Fayette St. was occupied by the seven-story concrete building now being taken down, the remaining space on Calvert St. by a small 3-story reinforced-concrete building, three years old, and the remaining Fayette St. front by a roofed cellar built a short time after the fire. The new building will occupy this entire space for a height of 18 stories above ground and two stories in basement. The preliminary operations involved the tearing out of the cellar building on Fayette St. and erecting thereon, for the temporary occupancy of the "News" force, four stories of the new building. This work was started March 22, 1910, and the office transferred to the temporary quarters about Feb. 1, 1911. This part of the building has been built up to the fourth story and temporarily shut off from the weather. It will be completed and connected up to the rest of the structure as that is erected. During this time the light, three-story reinforced-concrete building on Calvert St. was also removed. This building was taken down after the same manner as the larger building, as described below, but on account of its small size presented no particular difficulty, except in one particular. It was designed according to the Kahn system and the wing bars peculiar to that system proved to be a great obstruction in the way of effective chiseling of the concrete.

The old Baltimore "News" building was of the typical slab, girder and column reinforced-concrete type with front walls of cut limestone backed with brick and rear walls of brick. It was about 57 × 73 ft. in plan and seven stories and two basement stories in height. It was designed in the spring of 1904, by the Baltimore Ferro-Concrete Co., and built the following summer and winter by a local contractor, Mr. John Waters. The concrete structure is thus about 6½ years old. Except for some exceptionally heavy members to provide for the presses and for some peculiarities of layout, the design is of the type regularly adopted by its designers, viz., straight round rods, separately placed, in both beams and columns.

Fig. 2 is a plan of the second floor and shows the typical arrangement of the various members. The columns, around the outside walls and on one inside line, extended down about 30 ft. below street level where they were founded on stepped grillages of 10 to 24 in. I-beams, encased in concrete, and footing on the hardpan bottom. The columns vary from a maximum of about 30 ins. square at the footing to 10 ins. square at the roof, and are reinforced with round rods, distributed through the section according to the stress, tied together, about every 10 ins. with interlacing tie-wires. Connections of rods were made by butt joints, with a 14 or 16 in. length of gas-pipe sleeve covering the joint. A typical column section is shown in Fig. 2.

The press-room was located in the south section of the building, which accounts for the spacing of the columns there. The front beam, No. 15, was over a street show window, so it was necessary to span a full opening there of about 40 ft., at the first floor, but above that the wall span, was carried on four columns. The wide span, however, was carried up to the rear of this opening for the entire height, so that the girders "33" were needed on all floors. Girders "22," "19" and "18" were also of large size. The remainder of the beams were quite small, as shown.

All beams were reinforced with plain round rods in the lower plane with a portion bending up into the upper plane toward the supports, and with double-looped right angle stirrups. The girders are reinforced very heavily, as Fig. 3 shows. Girder "15," the facia girder on the Calvert St. side, was 36 ft. 2½ ins. in span between faces of supporting columns with a 2 ft. 9 in. cantilever on either side, one of which supported a column. In addition to carrying the floor slab, it carried the columns supporting the upper stories. On account of its ornamental position in the building, its section was very irregular, but as is shown, it was about 21 × 54 ins. in section and reinforced with a great number of very heavy rods, both in the upper and lower planes.

The floor slab was generally 4 ins. thick reinforced with ⅜-in. rods, running across the shorter span and spaced generally about 5 ins. on centers. The roof was of similar design, with a 3-in. thickness, and covered with a slag roofing.

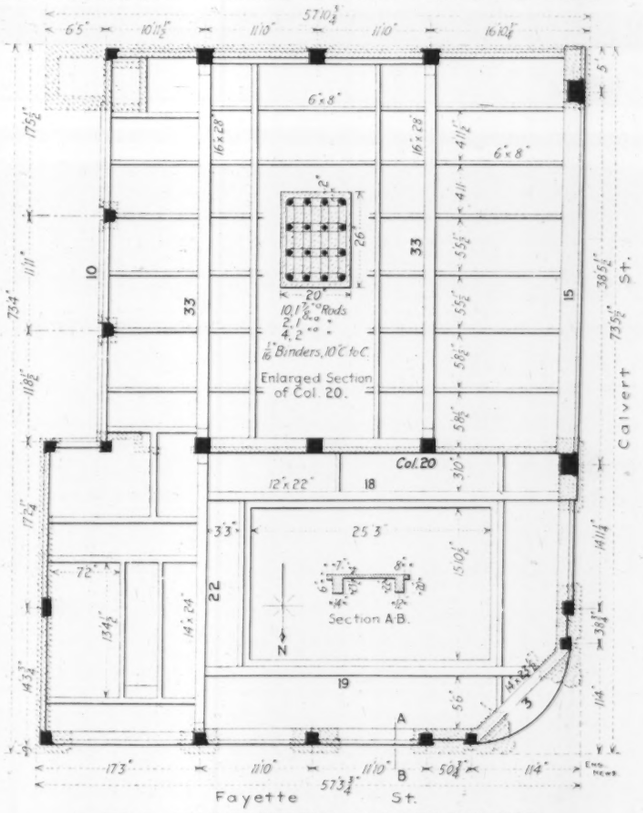


FIG. 2. PLAN OF SECOND FLOOR OF BUILDING.

(From original drawings.)

Methods of Destruction.

The old building was vacated on Feb. 8, 1911, and the contract called for its complete removal in 90 days from that time. Two weeks were spent in the preliminary operations of tearing out trimmings, fittings, partitions, floors, etc., so that the actual work of tearing down the structure did not commence until about Feb. 22. Since then the work has progressed at the rate of about 10 days to a story, so that the completion should be some weeks ahead of the contract time.

Work was started simultaneously at the roof in taking down the old skeleton and in the sub-basement in putting in the new foundations.

In the destruction of the building proper, the first step was to remove the limestone walls, from the roof down, by prying apart the separate stone and picking them up one by one with derricks and lowering them upon wagons in the street. The brick walls backing the stone facing were laid in lime mortar and could easily be torn apart, but the back walls of brick were laid in cement mortar and their removal was more of a job, requiring the use at times of air tools to break them apart. When all the facing walls were down the destruction of the skeleton was then started from the roof.

Briefly stated, the method of razing comprised first the smashing of the floor slabs by dropping a pile-driver hammer, the cutting of the concrete of the beams, girders, and columns by an air-driven chisel and the final separation of these members by cutting the steel with a gas-flame cutter. All cuts are made a sufficient distance in all directions from the column-beam-girder intersections to permit of the removal of a piece that can be conveniently handled on the horse-drawn wagons that cart the pieces away to the yard where they are smashed up and the steel bars scraped.

The slabs were broken by dropping a 2000-lb. hammer, slung from a derrick so as to get about a 6 ft. drop. This impact would shatter the concrete pretty thoroughly but would only occasionally break or bend a rod. After one or two blows the breakage would be complete enough to allow the edges to be removed and the panel cleaned up by the use of hand and air chisels. Fig. 4 shows a view of a floor panel from which the concrete has been removed. The rods are not cut until the adjoining beam is ready to be removed.

In removing the main members of the skeleton, the work was divided into the largest sections that would permit of removal by derrick and wagon, about 10 tons being a maximum. Usually the cut in the column was made just below the bracket and those in the beams spaced to get the proper size of pieces. First, all of the members in a given section were cut clear through the concrete with air-chisels, the width of the cut being made as small as possible, usually about 10 ins. Then the steel of the column was cut by the oxygen-gas flame, and the section supported from a derrick and blocked up from the floor below, while the cuts through the steel of the beams and girder were being made. As shown in Fig. 1, the work was carried on in steps from the Calvert St. side, so that the derricks could remain on the highest section of the building and be away from the street where the loading was done. The taking out of the concrete was faster than the carting away so a storage space for removed pieces was provided on the sidewalk bridge.

CONCRETE CUTTING.—The air-hammers used are of a light hand type, weighing about 6 lbs. and provided with ½-in. chisels of various point shapes. They are handled by ordinary laborers who soon become familiar with their use. Air at 125 lbs. pressure is supplied from two electric-driven compressors, located in different parts of the work. At one time 100 lbs. of air pressure was tried but it was found that 125 lbs. was more effective. Although the concrete is very hard there is no great difficulty in cutting through it where it is free from the rods, but in the closely packed metal, the operators find that the tools stick and bind and the progress is very slow. The clean cut that the tools make is well shown in Figs. 4 and 5.

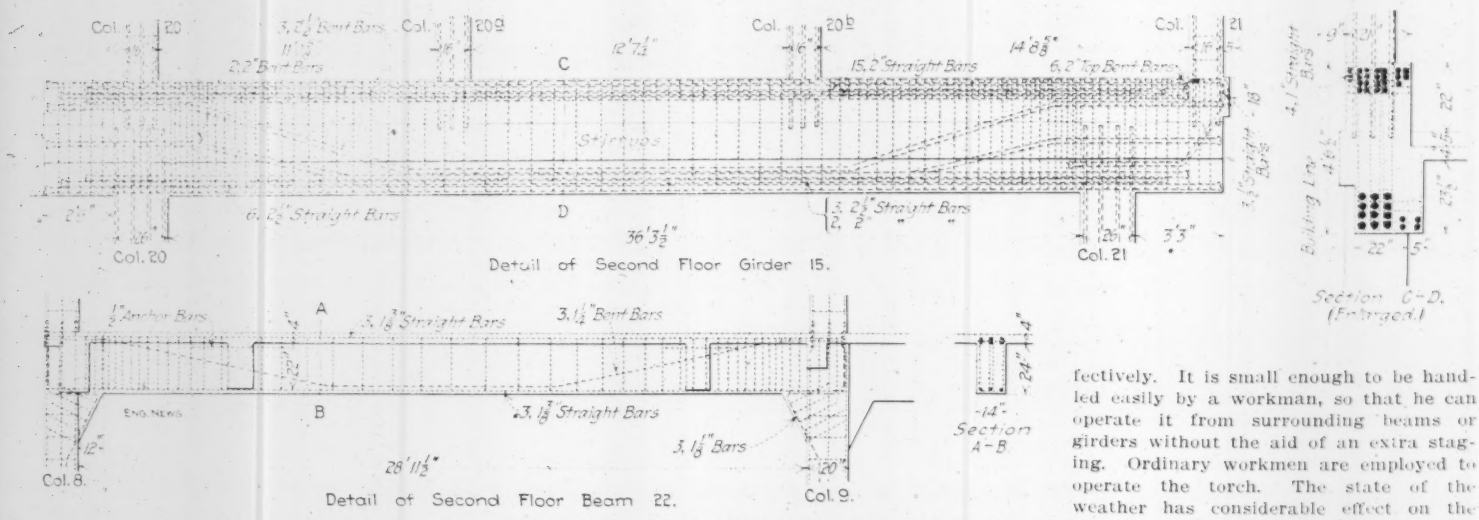


FIG. 3. DETAILS OF HEAVY MEMBERS SHOWN IN FIG. 2.

STEEL CUTTING.—All steel cutting is done with a blow-pipe and mixture of oxygen and coal gas, using the apparatus controlled by the Linde Air Products Co. Coal gas is used in preference to acetylene on account of its greater safety where the tanks are exposed to the changing temperature of a winter's day and because the tanks for the acetylene would require too great size and weight to be conveniently handled around the work. Each blow-pipe is provided with its own tanks, with a very short length of supply pipe so that tanks can be kept close to the cutting tool and the connecting pipes will not be apt to be cut or damaged by any falling pieces of concrete from other parts of the work. The blow-pipe, which first sends a flame of mixed oxygen and coal gas to heat the metal and then cuts through the softened part with the oxygen blast makes a very small kerf, perhaps 1-16 in. wide, and works very rapidly and effectively. It is small enough to be handled easily by a workman, so that he can operate it from surrounding beams or girders without the aid of an extra staging. Ordinary workmen are employed to operate the torch. The state of the weather has considerable effect on the effectiveness of the torch, it being found that on cold or windy days the speed of cutting was much lower than in ordinarily sunny weather.

Until the building is completely removed, the contractor prefers not to give out any figures of rapidity of work or the cost of cutting the concrete and steel. It was found, however, that the gas flame cut through the steel about eleven times as fast as a hack-saw.

FOUNDATIONS.—The new foundations were purposely arranged by the designers so as to interfere as little as possible with the existing footings, but in some places such interference was unavoidable. In these places it was necessary to cut through the old grillages of concrete-protected I-beams and to tear out the material so separated, so that excavation could be made for the new footings, which extended down some five feet deeper than the old. This foundation work comprised both the cutting off of some of the massive reinforced concrete columns by the air-drill and gas-flame methods used in the upper

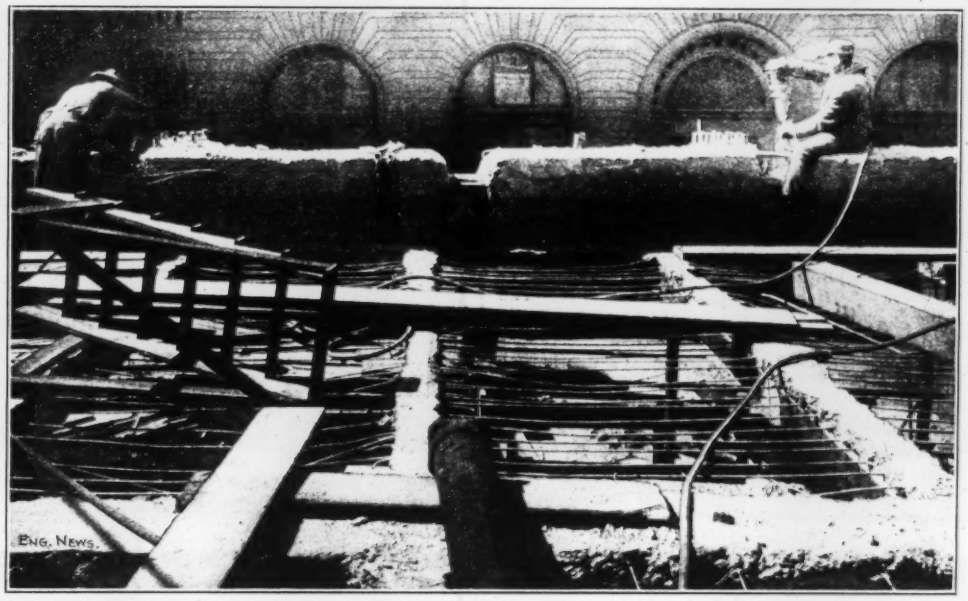


FIG. 4. VIEW OF SECOND FLOOR LOOKING WEST TOWARD LARGE GIRDER "15."

skeleton and the blasting away of the heavier concrete work around the grillage beams. Blasting was carried on, where the concrete was massive, small charges being placed in the early morning or in the evening when the adjacent streets and buildings were largely unoccupied. In many places the large I-beams were more easily handled by gas-flame cutting and the concrete removed by the air hammer. The new footings are now nearly all in place and the new steel columns can be started on them before all of the old concrete building is removed.

Condition of the Structure.

The first thing that strikes an observer in looking over the building is the very high percentage of steel used for reinforcement. A part of the building was used for a printing establishment and the heavy loads expected therefrom are no doubt responsible for some of this steel, but in spite of this there is undoubtedly much more than would be used to-day for a similar loading. The accompanying Figs. 2-3, reproduced from a portion of the original drawings used in the construction, shows some exceptionally heavy girders where the steel is far in excess of any similar design to-day, but even these girders are greater only in size than the typical beam used in the structure; the reinforcement percentage is only slightly higher than generally used elsewhere in the building. The girder "15" shown, has a steel percentage of 6.3% in the lower plane and 6.1% in the upper plane, a total of 12.4% or 140.6 sq. ins. of steel at the middle section. There does not seem to be any reasonable explanation for so heavy a reinforcement, particularly in the compression side of the beam. The girder shown in the view in Fig. 5 (not given in any drawings here shown) is 16 × 28 ins. in section and has twelve 1½-in. rods in its upper plane and sixteen 1½-in. rods in its lower, a percentage of 4.9% and 6.5%, respectively, or a total steel percentage of 11.4%. Necessarily such a great quantity of metal has resulted in its being bunched. The view in Fig. 4 shows in center cut in the big girder "15," with the great mass of compression steel in the upper flange. Fig. 5 is an end view of another girder, which has been removed from the building, and illustrates especially in the tension side, how close together it was necessary to place the rods. In any number of places the same condition may be noted, but in everyone where the rods do not actually touch, some mortar or grout has passed between the rods and is clinging tight to them. In such a beam as the one shown in Fig. 5 there is no adhesion to the concrete except along the sides of touching rods. The practical difficulties in placing rods according to drawings is well illustrated in Fig. 5. If anything, this section is a little nearer design position than most of those which can be seen on the building now. In some cases misplacement has resulted in the rods being only an inch or less from the face of the concrete, an obviously dangerous condition.

A typical column section is shown on Fig. 2. This column is the one shown in the view in Fig. 4 just in front of the workman operating the air chisel. Here, as in the beams, there is a very large percentage of steel.

CONDITION OF CONCRETE.—So far as can be now learned a 1:2:4 crushed granite concrete was prescribed for the building, though an engineer connected with the work states that a 1:2:5 mixture may have been used. It is a very good solid concrete, and all sections through it show a uniform, well-mixed mass. The superintendent of the wrecking gang states that the cutting by chisels was noticeably easier at the top floors than at the bottom, indicating a possible letting down of inspection and workmanship in the original concrete laying as the roof was approached. He also reports that the concrete found in the newer adjacent foundations was much harder to chisel than that in the main building, and that its additional strength seemed to be due to a larger cement content and better sand. However, aside from a possible excess of sand, the concrete of the skeleton is very acceptable. It might be noted that even in the largest and thickest pieces of concrete, no difference in the cutting speed was experienced as the center of the mass was reached.

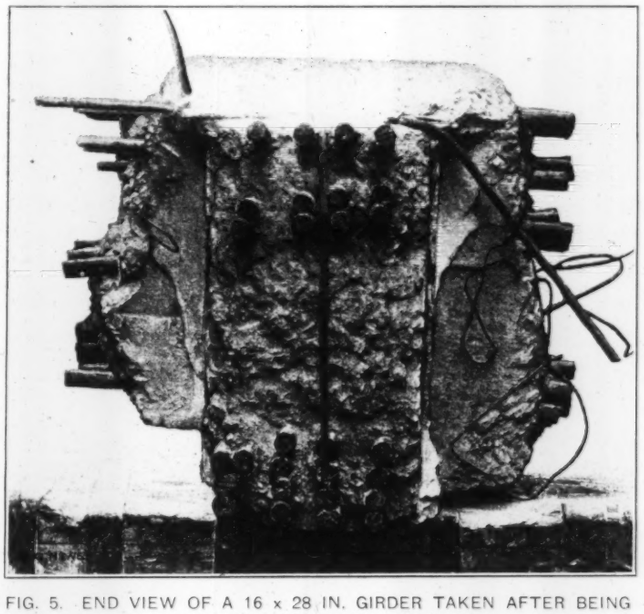


FIG. 5. END VIEW OF A 16 x 28 IN. GIRDER TAKEN AFTER BEING REMOVED FROM BUILDING.

CONDITION OF STEEL.—In all but a very few instances the steel is in perfect condition, as fresh and as bright as it was the day it was put in. The reinforcing rods are black and smooth and show no signs of rust or other attack, and the I-beams in the grillages still carry for the most part the coatings of protective paint. The exceptions to this general rule are to be found in a few grillage beams where the protective covering of concrete was only about ½-in. and on some floor and roof slab rods which were exposed to water.

The grillages are well under the ground water level. They were protected only by the concrete covering and that, in many places, was decidedly thin. In these thin places the water penetrated to the steel and despite the paint covering managed to pit it with the rust. In no case is this rust extensive, but it is none the less readily apparent.

The roof, a 3-in. reinforced-concrete slab, was covered with an ordinary slag roofing. In some places the concrete appeared none too dense and at such places some of the rods were slightly pitted with rust. It would seem that the roofing had leaked and the water which had passed through found some weak places in the concrete, through with it passed to the steel. Similar leakage occurred in some of the floors where shower baths were in constant use, and where the bath drain floor was not sufficiently separated from the concrete floor-slab. In none of these places had the rust gone beyond the pitting stage so that possible damage to concrete from the swelling of a rusting rod cannot be observed on this building. These rusted rods were not to be seen when the representative of Engineerings News was on the building and all that is here stated about them is on the authority of the superintendent for the contractors. At any event, the rusted rods are a very small percentage of those observed, and were in all cases in slab rods; the general condition of the steel is perfect.

The George A. Fuller Co. has charge of the work of removal as well as the erection of the new buildings, through its Washington office. Their superintendent on the building is Mr. J. G. Bent. The contractor received $22,000 for the razing of the building and in addition sold all salvage rights to one man for $1,500. This salvage includes all trimmings and fixtures as well as the material proper. Effort is being made to scrap the steel from the reinforcement, but it is understood that it is not proving economical. This is being done by smashing the pieces of beams and columns with a pile-driver hammer until the steel falls away. One remarkable feature of the work of destruction is that no workman has been seriously hurt by falling material.

Failure of Floors at the Harper Memorial Library; Chicago.

The failure of seven floors in one of the towers of the new Harper Memorial Library at the University of Chicago occurred on March 29. The building, which is approaching completion, fronts south upon the Midway, and has at each end a tower about 55x75 ft., with seven floors. The east tower was completed, and the west tower, in which the accident occurred, was nearly completed, all the floors being in place. In each tower the walls were of brick, with exterior stone facing; the columns are of steel (Gray section) to the fourth floor and of reinforced-concrete above. Between the columns are reinforced-concrete girders which support floor slabs, 16 to 20 ft. square. The slabs had reinforced-concrete ribs alternative with flat-arch hollow-tile ribs. The floors were designed for a loading of 75 lbs. per sq. ft.

We are informed that the age of the concrete of the floors which failed was from three weeks to several months. Also, that the forms had not been struck for the more recently completed floors, and that where there was any special loading the shores had been continued to the basement. A stairway at the rear (north) of the tower afforded additional support, so that the failure did not extend to the north wall, but with this exception the failure made nearly a clean sweep of the interior. The concrete of the upper floors stripped clean from the reinforcing bars, many of which remained anchored in the north portion (still in place) and hanging down into the open space. The newest concrete (said to be three weeks old) showed a much darker color than that of the other floors, indicating that it had not fully set and dried out. The weather had been variable, with several mild days, but also cold days and nights.

A stiff-leg derrick was being erected on the top floor, and the steel boom had been laid temporarily on the top of the west (end) wall, where it remains. The timbers of the stiff-leg are now at the bottom of the tower. If the top floor gave way first, as seems probable, the impact of the wreckage and the heavy timbers would account for the failure of the other floors in succession. A large gap was torn in the upper part of the south (front) wall, but all the wreckage fell inside the walls. Several workmen were on a lower floor, but were warned by the sounds of failure and all escaped unhurt into the main building.

An investigation is being made, but up to April 1 nothing had been found to indicate the cause of the accident. One suggestion is that the shock and vibration caused March 9 by the powder explosion near Kenosha, Wis., the effects of which were felt in and beyond Chicago, may have affected the recently placed concrete of the upper floors, impairing its cohesion and its adherence to the reinforcing bars. The architects are Shepley, Rutan & Coolidge, of Boston and Chicago, and the Wells Brothers Co., of Chicago, had the contract for the work.

A 12-IN. STEAM PIPE BURST March 27 at the new power-house of the Amoskeag Manufacturing Co. at Manchester, N. H. One man was killed outright, and two of the eight others injured died within a few hours. Reports state that the rupture occurred at a "dead-end" of the pipe.

DYNAMITERS made an unsuccessful attempt to wreck the tower of one of the new municipal buildings at Springfield, Mass., April 4. The tower is described in press reports as a massive brick structure. The explosive was placed against the outside of the tower near its base. A hole between three and four feet in diameter was made through the wall, but reports state it can be easily repaired.

DANGER OF WATER SHORTAGE IN NEW YORK City during the coming year was announced on March 27 by Mr. Henry S. Thompson, Commissioner of Water Supply, Gas and Electricity, in a letter to Mayor Gaynor, as follows:

I believe that the time has arrived when we should take the public into our confidence and let them know the small amount of water there is in reserve at the present time upon which the Boroughs of Manhattan and The Bronx depend.

We have now on storage 40 billion gallons as against 90 billion gallons at the end of March last year. Our present storage is equivalent to about 120 days' supply. The rainfall for the months of December, January, February and March of a year ago was 18.1 ins. For the corresponding months of this year, the rainfall has been only 10.6 ins. In addition to this there was practically no rain last summer and fall.

A SPEED OF 90.2 MILES AN HOUR was made with a monoplane flyer by Pierre Vedrine on March 31 in a flight from Poitiers to Issy-les-Moulineaux, France. The distance is about 208 miles and was covered in 132 minutes.

THE WORKMEN'S COMPULSORY COMPENSATION law of New York State was declared invalid by the highest court of the state on March 24. The law was passed last year. It classified certain occupations as dangerous and required employers of labor in such occupations to compensate for injuries to their employees in the work irrespective of questions of workman's negligence or employer's fault. The court held that an established property right is injured by this law, and therefore the law is unconstitutional. The property rights referred to appear to be those rights of an employer under common-law practice which absolves him from responsibility in case of contributory negligence, etc. The court appears to hold that only a constitutional amendment can alter the rules of judicial practice in such cases. The case which brought out the decision was a suit by a railway switchman for compensation for an injury which he claimed in his suit was the result of the necessary risks of his occupation.

THE LOETSCHBERG TUNNEL THROUGH THE ALPS was holed through at 3.50 a. m. on March 31. In spite of several unlooked-for difficulties the work will probably be completed in contract time. The tunnel as originally planned was a tangent 8½ miles in length; but on the choking up of over a mile near the northern end of the tunnel with sand, gravel and water on July 24, 1908, a change in alinement was made, by a swing to the east, to avoid the material encountered in the first location. In this accident 25 workmen were killed and all the drills and equipment lost beyond all hope of recovery. This detour increased the length of the tunnel to 9.04 miles. The tunnel will be operated electrically with a 15,000-volt single-phase alternating-current of 16 cycles. It is to be double-tracked throughout, making it the second longest double-track tunnel in Europe, the St. Gothard being the longest. The work on the northern end was begun on Oct. 15, and the southern end Oct. 28, 1906. The contract calls for its completion by September, 1911. It is the third longest tunnel in Europe; the Simplon being 12.25 miles and the St. Gothard 9.25 miles long. An article describing the Loetschberg tunnel was published in our issue of Jan. 5, 1911, by Mr. E. L. Corthell, M. Am. Soc. C. E. The methods used in tunneling, by which some records for very fast work were made, were described in our issue of Dec. 31, 1908, by Mr. W. I. Aimes, M. Am. Soc. C. E.

THE WATERFRONT ELEVATED RAILWAY SCHEME which has been discussed in New York City for a dozen years or more is probably shelved for a long time by a new study of the New York freight traffic problem. Mr. H. P. Nichols and Mr. E. P. Goodrich, working on behalf of a committee of the city's Board of Estimate on the question of removing the New York Central & Hudson River R. R. surface tracks in Eleventh Ave., have concluded an elevated railway on West St. or Eleventh Ave. to be undesirable and uneconomical, and recommend instead a freight subway in Eleventh Ave., from 60th St. to 30th St. yard, to be built by the New York Central for its own exclusive use, and in the district south of 30th St. a series of car-transfer piers connected by elevated railway with inshore freight delivery and storage warehouses. The pier and warehouse combination they call a "Unit Terminal," and by its means, they claim, all the railways reaching New York City will be able to secure the cheapest and most expeditious and convenient means of handling their freight into and out of New York City. The West Street elevated railway scheme has most recently been advocated by Mr. Calvin Tomkins, the city's Commissioner of Docks and Ferries, who proposed as an auxiliary thereto a great series of terminal and storage warehouses above 24th St., to be served from the elevated railway and to handle all the freight of the west side of the city. This scheme did not succeed in finding much favor with either the city or the affected corporate interests. Three members of the Board of Estimate having now come out against it and endorsed the Nichols and Goodrich plan, the elevated-railway scheme is probably dead.

Personals.

Mr. C. E. Knickerbocker, M. Am. Soc. C. E., formerly Engineer of Maintenance-of-Way of the New York, Ontario & Western R. R., has been promoted to be Chief Engineer of the same road.

Mr. Elmer B. Tol-tead, formerly Assistant Engineer in the Mine Rescue division of the U. S. Bureau of Mines, has joined the staff of the Independence Inspection Bureau of Philadelphia.

Mr. Algernon B. Alderson, Assoc. M. Am. Soc. C. E., and Mr. Albert S. Brainard, Jun. Am. Soc. C. E., have formed a partnership for the practice of civil engineering with offices in the Phoenix Bldg., Hartford, Conn.

Mr. J. R. E. Turpin, formerly Assistant Engineer with the Union Pacific R. R., and Mr. Lyman Eldridge, formerly Assistant Engineer with the New York Central & Hudson River R. R., have formed a partnership for the practice of civil engineering with offices in the Haynes Bldg., Rawlins, Wyo.

Mr. Carl Maughmer, Assoc. M. Am. Soc. C. E., formerly Assistant Engineer, State Department of Engineering, Sacramento, Cal., and Mr. George S. Nickerson have formed a partnership for the practice of civil and hydraulic engineering with offices in the Ochsner Bldg., Sacramento, Cal.

Mr. A. H. Allen, for the past seven years Manager of the Bridge Department of the Minneapolis Steel & Machinery Co., has organized the International Bridge & Iron Co., with offices in the Plymouth Bldg., Minneapolis, Minn., as Engineers and Contractors for structural steel and foundation work.

Mr. W. H. Kirkbride, Division Engineer of the Coast Division of the Southern Pacific Ry., at San Francisco, Cal., has been transferred to the Sacramento Division, with office at Sacramento, Cal., to succeed Mr. G. B. Herington, who resigned, as noted in these columns on March 16. Mr. E. C. Morri-on, Division Engineer of the Shasta Division, succeeds Mr. Kirkbride at San Francisco.

Dr. Alexander Smith, Professor of Chemistry and Director of the Laboratories of General and Physical Chemistry at the University of Chicago, has been appointed Professor of Chemistry at Columbia University to succeed Dr. Charles F. Chandler, who retires on June 30, after 47 years' service. Dr. Smith was born in Edinburgh, Scotland, and is a graduate of Edinburgh University. He received his doctor's degree from the University of Munich in 1889.

Mr. John F. Stevens, M. Am. Soc. C. E., has resigned as President of the Oregon Trunk Ry., and other railways of the Hill System in Oregon. He is succeeded by Mr. Carl R. Gray, Senior Vice-President of the St. Louis & San Francisco R. R., of St. Louis, Mo. Mr. W. C. Nixon, Vice-President and General Manager of the St. Louis & San Francisco R. R., succeeds Mr. Gray, and Mr. W. T. Tyler, General Superintendent at Springfield, Mo., succeeds Mr. Nixon as General Manager.

Dr. R. W. Raymond has resigned his position as Secretary of the American Institute of Mining Engineers. He has been relieved from executive and administrative duties and appointed Secretary Emeritus of the council, his services being retained by the institute for special editorial duties. Dr. Raymond was one of the founders of the institute in 1871. He was elected Vice-President in that year and became President upon the resignation of David Thomas. He was successively re-elected to the presidency in 1872, '73 and '74. He was first made Secretary in 1883 and has since served continuously in that position. Dr. Joseph Struthers, who has been Assistant Secretary of the institute for the past eight years, has been made Secretary to succeed Dr. Raymond.

Obituary.

Ellen H. Richards, wife of Prof. Robert H. Richards, of the Massachusetts Institute of Technology, and famous as a sanitary chemist and writer, died in Boston, Mass., on March 30. A biographical sketch of Mrs. Richards appears elsewhere in this issue.

David Brown, Assistant Superintendent of Motive Power of the Delaware, Lackawanna & Western R. R., died on April 2 at Scranton, Pa. He was born on May 17, 1838, in Canada. His early railway experience was gained in England, where at the age of 13 years he began as a messenger boy for the Monmouthshire Ry. & Canal Co. From this position he rose by degrees through the mechanical department to foreman at the main shops of the company in 1864. After serving a while as engineer of a steam-ship, he settled in this country and in 1870 became a machinist for the Delaware, Lackawanna & Western R. R. From this position he was promoted to gang foreman, foreman of erecting shop, general foreman, and in 1901 was appointed Assistant Master Mechanic, and a few years later Master Mechanic and Assistant Superintendent of Motive Power.

George Bowers Caldwell, M. Am. Soc. M. E., for many years a prominent mechanical engineer with the Westinghouse, Church, Kerr & Co., of New York City, died at his home in Yonkers, N. Y., on March 31. He was born in Lawrence, Mass., in 1863. For a number of years he served in the machine shops of the Lawrence Mfg. Co., of Lowell, Mass., and the Washington Mills Co., of Lawrence, Mass. He became connected with the Westinghouse, Church, Kerr Co. in 1893, and was engaged in the design of numerous important works, including the mechanical and electrical features of the South Union Station, Boston, Mass., the terminal station of the Pittsburg & Lake Erie R. R. and the shops at McKees Rocks, Pa., and the Kingsbridge power station of the Third Ave. R. R. of New York City. He supervised the design and installation of the Long Island R. R. electrification system, including the power-house at Long Island City and the mechanical and electrical features of the Pennsylvania R. R. station in New York City. This latter work he was obliged to relinquish before completion because of failing health. He was also a member of the American Society of Civil Engineers and of the Masonic fraternity. He leaves a widow and four children.

Engineering Societies.

COMING MEETINGS.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 15-18. Annual meeting at Chattanooga, Tenn. Secy., D. B. Sebastian, 721 La Salle Station, Chicago, Ill.

AMERICAN RAILWAY ASSOCIATION.
May 17. Semi-annual meeting at New York City. Secy., W. F. Allen, 24 Park Pl., New York City.

OHIO SOCIETY OF MECHANICAL, STEAM AND ELECTRICAL ENGINEERS.
May 18-19. Annual convention at Youngstown, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 23-25. Annual meeting at New York City. Secy., F. H. Wentworth, 87 Milk St., Boston, Mass.

AIR BRAKE ASSOCIATION.
May 23-26. Annual convention at Chicago, Ill. Secy., F. M. Nellis, 53 State St., Boston, Mass.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 23-26. Annual convention at Pittsburg, Pa. Secy., Richard Moldenke, Watchung, N. J.

INTERNATIONAL MASTER BOILERMAKERS' ASSOCIATION.
May 23-26. Annual convention at Omaha, Neb. Secy., H. D. Vought, 62 Liberty St., New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
May 29-June 2. Annual convention at New York City. Secy., T. C. Martin, 29 West 39th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
May 30-June 2. Annual convention at Pittsburg, Pa. Secy., Calvin W. Rice, 29 West 39th St., New York City.

ENGINEERS' CLUB OF ST. LOUIS.—At the regular meeting of April 5, Mr. A. A. Aegerter presented a paper entitled "Some Engineering Features of the St. Louis Building Laws."

NEW ENGLAND WATER WORKS ASSOCIATION.—A special meeting will be held at Springfield, Mass., in the Hotel Kimball, April 12. The general subject of fire protection will be discussed by Wm. H. Daggett, Chief of the Springfield Fire Department, Mr. E. V. French, Vice-President and Engineer, Arkwright Mutual Fire Insurance Co., of Boston, will present a paper on "Desirable Pressure at Hydrants."

NATIONAL METAL TRADES ASSOCIATION.—At the 13th annual convention April 12-13 in the Hotel Astor, New York City, the Thursday morning session (April 13) will be devoted to employers' liability insurance. A committee report on that subject will be presented by Wm. Butterworth, committee chairman, and will be discussed by Raynal C. Bolling, Miles M. Dawson and J. A. Macdonnell, all of New York City, and by H. V. Mercer, of Minneapolis.

NATIONAL ELECTRIC LIGHT ASSOCIATION.—Among those who are expected to address the public conference on water powers and their government control are John Bogart, H. M. Byllesby, H. L. Doherty, R. D. Mershon, S. Z. Mitchell, J. R. McKee, D. B. Rushmore, L. B. Stillwell and J. G. White. The conference is to be held April 8 at the Engineering Societies Building in New York City under the auspices of the power transmission section of the association.